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Final Performance Report

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Project 1 (FINAL)

Ensuring the Viability of the NY Allium Crop Industry by Meeting the Research and Outreach Needs for Controlling Leek Moth

Project Summary

Background and motivation for the study

Leek moth (LM) has been expanding its infested area rapidly since its first detection in 2009 in the US. In some areas of Europe, where LM originated, production of Allium crops has ceased because of the difficulty in controlling it. In other areas of Europe, the introduction of parasites has helped to control it, but such introductions into the US would take at least 5 years because of the needed research and permits. In the meantime, we must rely on other tactics such as insecticides and cultural practices like row covers. However, these practices are very time-sensitive and must be applied when the insect is a particular stage. Because all insects are cold blooded, their development (e.g., spring emergence, egg laying, larval feeding, number of generations, etc.) is tied to temperature. The accumulated heat units needed to produce a specific insect stage is calculated in degree-days (DD) and this can vary considerably within a region. Thus, it is imperative to have more localized weather data to determine the stage of LM in a specific area, one of our goals in this project. Previous research on leek moth in its native habitat, Europe, has shown that there can be up to 6 generations per year. While there would likely be fewer generations in northern NY, the warmer areas in other Allium producing regions of NY would produce more generations. Although degree-day models that predict the development of leek moth have been developed in Europe and Canada, it is unknown how applicable they are in NY. This project will develop and validate the degree-day model across the LM infested areas within NY as well as predict how many generations could be produced in other areas of NY where it does not yet occur.

The field efficacy of insecticides against LM has never been evaluated in NY and the literature from other areas does not provide much help in identifying effective insecticides. Our laboratory study in 2011 was the first to identify a broad range of potentially effective insecticides for LM. The project will test the field efficacy of insecticides in conjunction with application timing based on degree-day models. We were able to obtain special NY registration (2ee) for insecticides based on our assumption that they would work against LM, but such registration will not continue without field data. Thus, our trials will provide that data as well as help get newer products registered.

A major emphasis of the project was to evaluate non-insecticidal control for LM and thus trials were conducted with row covers that could be used by small-scale farmers. Studies were conducted that examined their efficacy in preventing LM injury as well as their potential effects on plant growth and marketability.

Another focus of the project was to develop an extension program that would help growers identify LM and its injury and utilize tactics to control it on the farm and help prevent its spread to other areas.

Project Approach

The project included a series of activities that would develop the knowledge for growers to utilize better management of LM.

The four primary activities were:

1. Develop and validate degree-day models for LM activity in NY to alert growers when pest management tactics would have to be implemented.
2. Conduct laboratory and field tests to evaluate insecticide and nematode efficacy against LM.
3. Evaluate row covers and their use for preventing LM injury.
4. Conduct an outreach educational program for *Allium* growers.

Significant accomplishments from activities

1. Based on field studies in 2013 and 2014, we developed and validated a degree-day model that can be used to predict the emergence of adult LM and their flights, thus providing warning to growers to implement control tactics. Farmers typically use weather information and the NYS IPM program utilizes such information for predicting insect development. Thus, we believe IPM can use the information we developed on LM to warn growers of impending developmental stages of LM so growers can take appropriate action.

2. Laboratory and field tests were conducted to evaluate the efficacy of insecticides and the use of nematodes for control. The nematode *Steinernema feltiae* did not curatively control LM in the field trial. The newly registered insecticide cyantraniliprole was very effective in controlling LM, as was Entrust for organic growers.

3. Row covers were effective at preventing an infestation and did not increase nor decrease yield when properly weeded.

4. A strong outreach effort was undertaken with many well-attended workshops and conferences. A pocket guide about LM and its management was published and distributed widely and the outreach education material was incorporated into the website, http://web.entomology.cornell.edu/shelton/leek-moth/

The postdoc responsible for the project was Masa Seto and he worked directly with Amy Ivy, the CCE educator in the LM-infested areas. They developed an excellent relationship with the local growers and other educators by working directly on grower farms. They also developed a good relationship with researchers and educators in Vermont as LM spread there.

Goals and Outcomes Achieved

The project was ambitious because it focused on developing biological information on the time of occurrence of LM, the efficacy of control tactics and the education of growers. Success was achieved for each goal and now growers are in a much better position to reduce losses to this devastating insect pest.

In 2013 and 2014 field data were collected from pheromone traps (for LM adults) and plants (for LM larvae), along with nearby temperature data. These data were combined with laboratory studies on the developmental stages of LM on various Allium plant species and a degree-day developmental model was constructed and successfully validated. This allows growers to predict when insects are present and in what development stage, so growers can time their control tactic. The results of the day-degree model were published in a journal so they are available to a wide audience (Seto, M. and A. M. Shelton. 2016. Development and evaluation of degree-day models for Acrolepiosis assectella based on hosts and flight patterns. J. Econ. Entomol. http://dx.doi.org/10.1093/jee/tov344. Published on line Dec. 2015).

Field, greenhouse and laboratory studies with the nematode Steinernema feltiae were conducted. A foliar application of S. feltiae to potted onions artificially infested with LM larvae caused a 64 % reduction in larvae. However, when a foliar application was made in the field, there was only a 1.4 % reduction of leek moth larvae with the nematode treatment. To understand this field result, additional laboratory studies determined that the efficacy of the nematode treatment was strongly affected by the developmental stage of LM larvae at the time of treatment with S. feltiae, with larger A. assectella larvae being more susceptible. Thus, it appears that control with this nematode might only be suitable onions that have already been damaged by LM. The results of these studies will be developed into a publication.

We evaluated the effect of row covers on preventing infestation by LM and whether the row cover affected yield. Row covers prevented infestation by LM. However, in some cases, depending on when the row cover was installed, yield could be affected. However, with proper management of the row cover, we believe we believe crop yield would not suffer. The row covers would not increase nor decrease yield when properly weeded. However, when the LM population pressure is high (80+ % of unprotected plants infested), the yield of plants under row covers can be 50% more than that of unprotected plants. When the infestation level is low (less than 20%), there was no significant difference in the yield. The results of these studies will be developed into a publication.

The extension outreach efforts were conducted in a series of workshops, on-farm demonstrations and regional presentations. The pocket guide to identifying and managing LM ("Leek Moth: Identification and Management Guide") was published in May 2014 and widely distributed and was well received. Due to the demand, it was reprinted in 2015. It is also available on the website we developed for LM management, http://web.entomology.cornell.edu/shelton/leek-moth/

A total of 25 workshops for farmers or extension personnel were conducted during the project. The size of the audiences varied depending on the workshop, but the total number of participants for all workshops was >600.

Because of the intense training efforts in Northern NY (with additional participants from other areas in NY and adjacent states), we believe that all commercial Allium farmers are now aware of leek moth and at least doing some level of monitoring for it and its damage. Monitoring is a major first step in adoption of pest management practices. Growers can time their sprays to monitoring and forecasting the presence of leek moth, while growers with more resources have adopted row covers as their primary control strategy. Virtually every commercial grower has benefited from the knowledge developed in this research project. Such knowledge, when well implemented, will provide financial benefit to them.

Beneficiaries

The beneficiaries are producers of Allium vegetables (onions, leek, garlic and chives) throughout NY. The value of these crops in NY is estimated to be >$75 million ($50 million for onions and $22 million for garlic alone). Besides large farms, Allium crops are important to roadside and CSA enterprises. Farms that are either conventional or organic, from small to large scale, were provided with information to help them implement tactics to prevent LM damage.

For conventional onion growers in New York, LM would be a new problem to deal with. However, conventional growers routinely spray for onion thrips and the materials they use are effective against LM, both preventively and curatively. Thus, the onion thrips management program simultaneously would provide LM management. If LM pressure is especially high in the early spring, growers can add one more spray before they initiate the spray program for onion thrips. However, it is rare for LM in NY to build up populations in the early spring. Thus, the conventional growers would not have to add any cost for LM even if it became a real problem.

For organic growers, the best strategy will be different depending on the scale. The small-scale organic growers (< half acre of Allium production) should choose row covers. If properly used, row covers will protect the crop season long. Many growers reuse the materials in the following seasons. They can be used multiple years and they are easy to mend. The large-scale organic growers (> acre of Allium production) should consider spray option. If they can provide enough labor to pull up the row covers and weed regularly, row covers can be an option. The number of spray needs to be minimized by referencing the degree-day model because there is only one effective organic insecticide (Entrust) in the market at present. If LM develops resistance to it, the organic growers will quickly lose effective options other than cultural practices.

Lessons Learned

LM was first identified in the north country of NY in 2009. The following year the project leader, Shelton, was able to get several insecticides labeled for it using the special registration FIFRA 2(ee). However, it was not until April 2014 that we received funding to begin a research/extension project on this important pest. One lesson that should be learned is that when a new invasive pest is detected that represents a serious threat to NY agriculture, there should be a mechanism within the state that will allow immediate funding to begin a research and extension program to prevent its spread.
Another lesson that we learned is the importance of having competent and dedicated extension staff on a project like this. Amy Ivy was an essential person in the project who provided connections with growers with whom we could cooperate.

Overall, I believe the project helped alert growers to the threat of LM and provided them with practices that helped prevent the wider spread of this new invasive pest. LM is here to stay and control practices for it need to be incorporated into the overall crop management practices for Allium crops. Our research indicates that this can be done effectively.

Additional Information

Pictures and information on LM management can be seen at the website we developed at

http://web.entomology.cornell.edu/shelton/leek-moth/index.html

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Project 2 (FINAL)

Increasing Profitability for the New York Onion Industry via Introduction of Novel Mild Hybrids Adapted to New York State

Project Summary

Mild onion production is potentially a highly profitable industry for NYS with significant growth potential since NY growers currently fill only 2% of NY mild onion demand. Recent attempts at increasing NY mild onion production were hampered by the lack of locally-adapted varieties that store well. The varieties currently available are short/intermediate day varieties developed for southern/western states. Unfortunately, these varieties are soft and store poorly. Use of better-storing mild varieties, which are adapted to NYS long-day conditions, would provide the basis for expanding the NY mild onion industry.

The Cornell onion-breeding program developed new long-day milder onion lines adapted to NYS with higher sugar (BRIX) for increased firmness and storability. Initial trials identified experimental hybrids that were as mild as current commercial mild onions, but with higher BRIX and longer storability. This positive development provided a timely opportunity to use novel hybrids as a basis for expanded testing that was needed to justify using such hybrids to expand mild onion production in NYS. The proposed researcher/ grower/chef collaboration tested these as well as additional hybrids and controls with growers across NYS for detailed analysis. The analysis included performance of direct seeded vs. transplanted trials, mineral and muck soil, mildness, BRIX, bulb size, storability and quality. In addition, an economic analysis was performed to determine the potential use of the locally-adapted hybrids by NYS growers to facilitate the production and marketing of these onions in NYS.

Project Approach

Stabilizing bulb color in mild red male parent using PCR based selection

The red male line used to create pink hybrids still had a low frequency of yellow (recessive) allele, so that yellow x red hybrid seed still had an unacceptable frequency of yellow bulbs among the pink bulbs. This would have also decreased uniformity of color for red x red hybrids.

The approach to stabilizing red color was to create a molecular marker for the appropriate bulb color gene, test to confirm that the gene targeted by the marker shows differences in yellow vs. red bulbs, and that the marker results accurately predicts bulb color. Once the marker was validated, it was used to select bulbs fully homozygous for red bulb color from a large population of bulbs of the red male line, and use these bulbs for production of seed of the improved red line, and also pink and red hybrids to be used in year 2 tests. This part of the project was fully successful.

Mutschler's lab technician, Darlene DeJong, created several PCR based markers to match the DFR gene controlling the last step in red color in onion bulbs. A set of DFR markers was identified as exactly matching color in bulbs from the red male line: all yellow bulbs were homozygous for the recessive yellow allele of DFR, and all red onions were either heterozygous or homozygous for the dominant red allele. Having proven the efficacy of the DFR primer to identify homozygous red bulbs, an isolation plot for pink and red hybrid seed production was established with yellow and red female lines, respectively, as well as 679 red male bulbs selected from over 2,000 bulbs based on bulb size, shape, and other qualities. The red male bulbs were tested using the DFR primer as they sprouted, revealing 145 heterozygous red bulbs, which were immediately removed from the field, leaving 534 homozygous red bulbs in the field for production of seed. Seed produced included seed from the homozygous red male fertile bulbs, creating a new red male line that is uniformly red. Other seed produced in the plot was seed of uniformly pink

hybrids (yellow female x red male line crosses) and uniformly red hybrids (red female x red male line crosses), for use in 2015 trials.

In addition to successful improvement of the red male line, and production of hybrid seed, the marker is also an outcome of this work. This DFR marker has been provided to seed companies, so that they could use it on other appropriate red onion populations to improve bulb color uniformity and color.

Production of seed of novel mild onion hybrids necessary for this project.

The seed of the novel onion hybrids for year 1 (2014) trials had been produced before the start of this project. The entries used for year 1 were Yellow Hybrid 1, Yellow Hybrid 2, and Pink Hybrid 1, and Pink Hybrid 2. The commercial control was Candy. In year 2, the uniform red line created, as described above, allow the production of pink hybrids improved for color uniformity as well as the first red mild hybrid, which were included in year 2 trials of this project.

Seed production uses bulbs grown the prior season and stored under cold (40° F) conditions to prepare the bulbs to flower. The bulbs were planted in isolation plots with each plot containing one or more different female parent entries but rows of only one male entry to provide pollen for seed production in that plot. As flowering scapes developed on the rows of male and female plants, Mutschler's crew provided trellising for support. Starting in June, routine preventive fungicide applications were applied to the plots, to protect developing seed from fungal disease. Scapes flowered, set seed after pollination by feral insects, and were harvested late August/early September into appropriate bags and hung for drying. Then seed was threshed, cleaned, dried, weighed, and stored in the Cornell state-of-the-art seed storage facility. Sufficient seed was produced to provide the needs of this project, as well as for distribution to additional groups (such as vegetable processing companies that run their own trials) to expand testing of the novel hybrids.

Sufficient seed of the now uniform red male line was produced to allow it to be released to seed companies under MTA for use in production of additional experimental pink or red hybrids.

Field trials of novel onion hybrids and controls, including testing feasibility of harvesting mild onions by machine vs. hand harvest

Two large trials, one in Elba NY, and one in Orange County, were conducted each year to test harvested bulb characteristics including bulb size, weight, percent marketable bulbs, reason for non-marketability (disease, doubling, damage, etc.), pungency, BRIX, and storability -- as described below.

Mutschler arranged with a commercial transplant grower to grow the mild onion transplants for the trials. Her crew also assisted with transportation of and planting of transplants in the trial in Orange County.

In Elba, large strip trials were conducted where the grower planted each entry using his standard planting configuration. In 2014, there were 4 double rows per bed with 15 inch row spacing, 3.25 inch between plants or 3.7 plants per foot. Since the plugs came with 3 plants per cell, the plant population was three-times higher than the grower's standard plant population (~ 129,000 plants/acre). In 2015, there were 2-row raised beds with 12 inch between rows on the bed and 30 inch between rows between beds with the same double rows in 2014. In 2015, plug transplants were produced with 1 plant per cell to better represent planting configurations of mild onions.

Christy Hoepting interacted with a grower in Elba area to receive transplants from the transplant grower, establish the bulb trial, oversee the plots during growth, undercut the onions to enhance dry down, then hand harvest sub-samples and oversee mechanical harvest. Prior to harvest in 2014, 5 sub-

samples of 100 randomly selected bulbs per entry were hand-harvested, removed from the field, dried in windrows in an open-sided barn until Mutschler's crew came to grade and weigh the bulbs. The remaining bulbs were mechanically undercut and windrowed and machine-harvested by the grower cooperator with his 8-row commercial harvester. Onions were harvested into bins by entry, where they were cured in the outdoors before being brought into the grower's commercial common storage in mid-November. The harvesting of onions was similar in 2015, except that 10 50-pound bags of onions were hand harvested for each of the hybrids in the trial that year, then the rest of the onions were machine harvested as described above. After all bulbs were harvested they were set for the curing process during September, with grading and continued assays following thereafter.

Maire Ullrich and Teresa Rusinek (year 1) or Kevin Besler (Year 2) interacted with a grower in Orange County to receive transplants from transplant grower and establish the bulb trial, also large strip trial, at that location. Teresa also interacted with the grower and provided labor to assure plots were weeded as needed for year 1; the year 2 plot did not have the need for extra weeding. They also interacted with the grower in Orange County area to undercut bulbs to dry fully before harvest. All onions were hand harvested and bagged. Onions were taken to Ithaca location for the curing process during September, for grading and continued assays thereafter.

Mutschler's crew transported onions to Ithaca, where they performed the grading of cured bulbs from both locations, collecting data concerning the size of the bulbs, uniformity for size, frequency of defect (such as damage, doubles or disease). They also assessed whether there was higher frequency of defects in the machine harvested vs. the hand harvested bulbs. Further indication on the impact, if any, of harvest method is provided by the storability test described below.

Harvest parameters of hybrids tested

All three of the new mild/increased Brix hybrids have the potential to produce a crop of which at least 90% is comprised of large and jumbo bulbs, and all of them could produce more than 65% jumbo bulbs (>2.9 in) in at least one location.

In the 2015 Orange County trial, Yellow #1 had the desirable combination of high % marketable bulbs and significantly higher percentage of jumbo bulbs than the other hybrids (Table 1). Red #1 had lower % marketable than the other entries, and also slightly smaller bulbs.

All entries in the 2015 Elba trial were comparable for % marketable bulbs, and Yellow #1, Pink #2 and Red #1 all had significantly higher % jumbo bulbs than the commercial Candy control (Table 2 and Table 3). There was no visually obvious damage to bulbs that were machine harvested vs. hand harvested at the first grading, which is in agreement with the results of the 2014 Elba trial. All of the pink bulbs were pink, and all red onions were red.

Bulbs of the red male line itself were also grown in Oswego; since they were also all red, this demonstrated that the marker assisted refining of the male line to remove low level presence of the yellow allele of the DFR gene was successful.

Table 1. Hand harvested bulbs from 2015 mild onion transplant trial, Orange County

Entry	% of Total No. of bulbs MKT	% Total weight of bulbs MKT	Ave weight large MKT bulb (gm)	Ave weight jumbo MKT bulb (gm)	% of MKT bulbs large	% of MKT bulbs jumbo	% of MKT bulbs large or jumbo	% weight MKT bulbs large	% weight MKT bulbs jumbo	% weight MKT bulbs large or jumbo
yellow #1	95.3 A	95.2 A	168.6 AB	266.5 AB	31.6 B	65.4 A	97.0 A	23.4 B	75.6 A	99.0 A
yellow #2	96.1 A	96.0 A	171.7 AB	271.6 AB	40.9 AB	54.7 AB	95.5 A	32.1 AB	66.4 AB	98.4 AB
red #1	89.4 B	88.0 B	158.6 B	255.9 B	48.5 A	42.0 B	90.5 A	41.4 A	54.5 B	95.9 B
pink #2	93.6 A	93.6 A	174.3 A	279.6 A	49.3 A	44.5 B	93.8 A	40.8 A	56.6 B	97.5 AB

Levels not connected by same letter are significantly different.

Yellow #2 only grown in Orange County. Candy control was grown here, but was accidently destroyed by grower.

Table 2. Hand harvested bulbs from 2015 mild onion transplant trial, Elba, NY

Entry	% of Total No. of bulbs are MKT	% Total weight of bulbs MKT	Ave weight large MKT bulb (gm)	Ave weight jumbo MKT bulb (gm)	% of MKT bulbs large	% of MKT bulbs jumbo	% of MKT bulbs large or jumbo	% weight MKT bulbs large	% weight MKT bulbs jumbo	% weight MKT bulbs large or jumbo
yellow #1	97.2 A	97.8 A	138.8 B	223.7 B	22.1 B	73.7 A	95.8 A	16.0 B	82.4 A	98.4 B
pink #2	98.2 A	98.5 A	152.0 AB	262.9 A	28.4 AB	68.3 A	96.7 A	19.4 AB	79.6 A	98.9 A
red #1	99.6 A	99.7 A	158.4 A	257.8 A	26.0 B	67.1 A	93.2 A	19.2 AB	78.6 A	97.8 AB
candy #1	96.3 A	96.5 A	147.5 AB	267.5 A	38.4 A	51.6 B	90.0 A	28.3 A	67.5 B	95.8 B

Levels not connected by same letter are significantly different.

Table 3. Machine harvested bulbs from 2015 mild onion transplant trial, Elba, NY

Entry	% of Total No. of bulbs are MKT	% Total weight of bulbs MKT	Ave weight large MKT bulb (gm)	Ave weight jumbo MKT bulb (gm)	% of MKT bulbs large	% of MKT bulbs jumbo	% of MKT bulbs large or jumbo	% weight MKT bulbs large	% weight MKT bulbs jumbo	% weight MKT bulbs large or jumbo
yellow #1	98.1 A	98.5 A	137.8 B	228.8 C	21.3 B	74.8 A	96.1 A	14.6 B	84.1 A	98.7 A
pink #2	94.8 B	95.8 A	162.0 A	266.9 A	29.7 B	66.7 A	96.4 A	21.2 B	77.8 A	98.9 A
red #1	95.9 AB	96.6 A	165.2 A	267.5 A	27.0 B	72.0 A	99.1 A	18.8 B	80.8 A	99.7 A
candy #1	97.6 AB	97.6 A	139.8 B	254.2 B	42.5 A	35.4 B	77.9 B	37.2 A	53.8 B	91.0 B

Levels not connected by same letter are significantly different.

Testing relative pungency and sugar content of bulbs as determined by laboratory assays

As grading was performed, samples of each replicate of bulbs of each entry at each location were collected for use in laboratory analysis of level of pungency/mildness and also for sugar level (BRIX) by Darlene De Jong in Mutschler's lab. These trials were performed in November or December, depending on the year. Over several years trials, the two yellow hybrids (Yellow #1 and Yellow #2), have reliable reduced pungency, as low or lower than that of the commercial mild onion Candy, which is as desired, but the yellow hybrids have increased BRIX by up to 30%, which is associated with increased storability. The expanded trials in 2014 and 2015 were meant to confirm the prior results of more limited testing

Analysis of the data from the 2014 Season agree with previous results, from when the mild lines were created, showing that the two yellow hybrids (yellow 1 and yellow 2), have reliable reduced pungency, similar to that of the commercial mild onion Candy, which is as desired, but the yellow hybrids have increased Brix (about 30 to 35%), which is associated with increased storability. The pungency level of the pink hybrid is not numerically as reduced as the yellow hybrids, but the difference in pungency levels among the yellow and pink hybrids is seldom statistically significant. The Brix level of the pink hybrid is generally even higher numerically than that of the two yellow hybrids (which is good), but this difference is not always significant.

The results in 2015 were also in general agreement with prior results. The Candy control was lost in the Orange Country trial (Table 4), however, pungency and BRIX levels of the test hybrids in Orange County were similar to those in the Elba trial (Table 5). The BRIX levels of all three experimental hybrids at Elba were significantly higher than that of the commercial control Candy. This is consistent with their improved storability.

Table 4. Analysis of pungency (mM) and BRIX in Orange County, hand harvested

Level	Pungency (pyruvate mM)	BRIX
red #1	10.3 A	8.2 A
pink #2	8.3 B	7.7 B
yellow #2	7.5 BC	7.0 C
yellow #1	7.6 C	7.0 C

Levels not connected by same letter are significantly different

The pungency levels of the Yellow #1 hybrid and the Pink #2 hybrid were equivalent to (hand harvest) or significantly lower (machine harvest) than that of the Candy control (Table 5), which agree with trials in 2014 for the yellow hybrid (the pink hybrid was not grown in 2014).

Table 5. Analysis of pungency (mM) and BRIX, Elba, hand and machine harvest

	Hand Harvest		Machine Harvest	
Level	Pungency (pyruvate mM)	BRIX	Pungency (pyruvate mM)	BRIX
red #1	9.8 A	8.7 A	8.9 A	8.3 A
pink #2	8.2 B	7.7 B	7.8 B	7.4 B
yellow #1	7.5 C	7.4 B	7.8 B	7.2 B
candy #1	8.0 BC	6.7 C	8.5 A	6.6 C

Levels not connected by same letter are significantly different.

The red hybrid was significantly higher than all other entries for BRIX. However, the Red #1 hybrid was also the highest of the experimental hybrids for pungency, and pungency of the Red #1 hybrid was significantly higher than Candy for the hand harvested bulbs. This relationship mirrors that seen in prior tests of the male lines themselves (the two yellow DH male lines vs the red conventionally bred line).

There are too few lines here to claim a trend, however, considering the difficulty in selecting for low pungency on a single bulb basis during conventional breeding, selecting for low pungency in DH lines (which are genetically fully inbred) is probably more likely to reveal lines stable for this complex trait.

It is possible that pungency could be affected by harvest method, since the level of the pungent compounds increase when tissues are macerated. However, the only significant difference in pungency level by harvest method was for the hand vs machine harvested Red #1 (Table 6). For all entries, BRIX was not significantly different whether the bulbs were harvested by hand vs. machine (Table 6). The lowest BRIX levels were seen in Candy, and all of the machine harvested experimental hybrids stored significantly better than machine harvested Candy (Table 5). The BRIX levels of Candy were not affected by harvest method (Table 7) but the percent loss level was significantly higher in Candy when machine harvested (Table 4). So this difference was not due to difference in BRIX, but to a different cause, perhaps the soft Candy bulbs suffered greater bruising when machine harvest than the firmer experimental bulbs.

Table 6. Comparison of machine vs. hand harvested bulbs from Elba NY

harvest method by entry	**Pungency (pyruvate mM)**		**BRIX**	
[Elba - hand harvest] red #1	9.8	A	8.7	A
[Elba - machine] red #1	8.9	B	8.3	AB
[Elba - hand harvest] pink #2	8.2	BCD	7.7	BC
[Elba - machine] pink #2	7.8	CD	7.4	C
[Elba - hand harvest] yellow #1	7.5	D	7.4	C
[Elba - machine] yellow #1	7.8	D	7.2	CD
[Elba - hand harvest] candy #1	8.0	CD	6.7	DE
[Elba - machine] candy #1	8.5	BC	6.6	E

Levels not connected by same letter are significantly different

Determining relative storability of hybrids, by percentage lost/maintained in storage

In the Elba trials, to further measure the impact of machine harvesting, immediately after grading, the bulbs were put into temperature controlled units (40^{o}F) for storage until January when they were re-graded to determine the storability of the new mild hybrids. Lack of storability is reflected in weight loss of the onions due to moisture loss. However, if onions were damaged during machine harvest, there would be greater loss due to the deterioration of onions that were bruised.

Analysis of the data from the 2014 season trial in Elba clearly show that the percent loss by both the yellow hybrids and the pink hybrid were low (6 to 13%) and consistent with the percent loss of moderately storing onions, and lower than the losses typically experienced with traditional short storing mild onions. Comparison of average % weight loss in storage of hand harvested vs machine harvested bulbs across entries shows no significant differences (with means being 9.9 and 9.4% respectively). Therefore, there were no detrimental effects of machine harvest of the hybrids tested in 2014. The results of the trial for the 2015 field season will be available in January of 2016 after they are graded out of storage.

For the 2015 trial, bulbs were put into temperature controlled units (40F) for storage immediately after fall grading, and held there until January when they were re-graded to determine the storability of the new mild hybrids. Lack of storability is reflected in weight loss of the onions due to moisture loss. The impact of machine harvesting, if any, could also be reflected in the storability data; if onions were damaged during machine harvest, there could be greater loss due to the deterioration of bruised onions.

The 2015 season trial in Elba clearly show that the percent loss by the experimental milder/higher BRIX yellow, pink and red hybrids was low (4.5 to 7.3%) (Table 7) which is similar to the percent loss of moderate-storing pungent onions. Comparison of average % weight loss in storage of hand harvested vs machine harvested bulbs at Elba across the new experimental entries shows no significant differences due to harvest method for the experimental hybrids; the higher BRIX milder hybrids, were firmer due to increased BRIX, and therefore could withstand machine harvesting without increased visual damage and without increased loss in storage. However, the standard mild onion hybrid Candy showed significant increased loss in storage for the machine harvested bulbs vs hand harvested bulbs (Table 8). This demonstrates the advantage of selecting for increased BRIX while breeding low pungency onions.

Table 7. Hand harvested bulbs from 2015 mild onion transplant trial, Orange County

Entry	% of stored weight lost in storage		
	Hand harvested bulbs, orange co	Hand harvested bulbs, ELBA	Machine harvested bulbs, ELBA
yellow #1	3.7 B	5.5 B	4.5 B
pink #2	9.2 A	5.8 B	6.2 B
red #1	7.1 AB	7.3 AB	6.1 B
candy #1		12.9 A	22.0 A
yellow #2	5.8 AB		

Levels not connected by same letter are significantly different.
Yellow #2 only grown in Orange County. Candy control was grown here, but was accidently destroyed by grower.

Table 8. Comparison of machine vs. hand harvested bulbs Elba, NY

[Harvest method) by entry comparisons	**Least Square Mean for % of weight lost in storage**
[Machine] candy #1	22.0 A
[Hand] candy #1	12.9 B
[Hand] red #1	7.3 B
[Machine] pink #2	6.2 B
[Machine] red #1	6.1 B
[Hand] pink #2	5.8 B
[Hand] yellow #1	5.5 B
[Machine] yellow #1	4.5 B

Levels not connected by same letter are significantly different

Testing cooking quality of onions, through evaluation by executive chefs

We have completed reports on onion use by three executive chefs, two in the NY city area, one in Rochester, NY using bulbs supplied from our trials. We provided bulbs from the 2015 season trial to a large marketer (Wholefoods) and additional chefs for additional evaluation. We will merge the results of both years evaluation for reporting/publication.

There was also one processing company (Amy's Kitchen) that had bulbs of Yellow hybrid #1 and Yellow hybrid #2 grown by their own contracted growers for their evaluations using seed provided to them. The results of the 2015 season trial were sufficiently positive that they have requested seed for continuing trialing in 2016 to decide if they want to adopt one of the hybrids for their future use.

Wide distribution of results, bridging seed companies, growers, marketers

A number of venues were used in year 1, year 2 or both to distribute the results of this project as widely as possible to seed companies, growers, and marketers

a. *2014 NYS Expo:* The EXPO was in the ONCENTER, in Syracuse, NY from Jan 20 to 22, 2014, Christy Hoepting was one of the organizers of this 3 day series of concurrent meetings, and she also chaired the Onion session, which was a day long set of presentations on Jan 22, 2014. Martha Mutschler presented a seminar in the onion session, regarding the trialing of mild onion adapted to NYS, telling about the NCSCG funding for the project, and the trials that would be run in the 2014 season. There were 94 attendees present.

b. *2015 NYS Expo*: The EXPO was in the ONCENTER, in Syracuse, NY from Jan 19 to 22, 2015. Christy Hoepting chaired the Onion session, which was a day long set of presentations on Jan 22, 2015. Martha Mutschler presented a seminar in the onion session, regarding the trialing of mild onion adapted to NYS, telling about the NCSCG funding for the project, and the trials that would be run in the 2015 season. There were 89 attendees present.

c. Orange County Onion School: The onion school was held March 7, 2014 in Middletown, NY. It was organized by Maire Ulrich, and was attended by 50 onion growers, largely from the southeast portion of NYS. Martha Mutschler presented a seminar on the trialing of mild onion adapted to NYS, telling about the NCSCG funding for the project, and the trials that would be run in the 2014 season.

d. Hudson Valley Commercial Vegetable Growers' School: The vegetable school was held February 24, 2015 in Middletown, NY. It was organized by Maire Ulrich and was attended by over 60 vegetable growers, largely from the onion producing region of Orange County. Brian Leckie, from Mutschler's lab, presented a seminar on the trialing of mild onion adapted to NYS, telling about the NCSCG funding for the project, the trials from 2014, and the trials that would be run in the 2015 season.

e. The onion council meeting was held at Cornell University in Ithaca NY (Feb 12, 2014). The onion council met with researchers working on onion diseases, insects, weed management, and quality and production parameters. Martha Mutschler presented an overview of the onion breeding program, including the mild onion trialing project, and plans for the 2014 growing season. Christy Hoepting also attended and participated at this meeting. A progress report was provided to the onion council in January of 2015, and we plan to present the results of the entire project at the 2016 onion council meetings. There were 24 attendees present.

f. The annual report of the Vegetable Breeding Institute (association of vegetable breeders at Cornell University and University of Wisconsin- Madison) was distributed to over 50 national and international vegetable seed companies in January of every year. The results of the development and trialing of mild onion adapted to NYS, telling about the NYSCG funding for the project, and the trials that were be run in the 2014 season was included in the January 2015 report by Mutschler. A report on the development of the DFR marker for red color, and its use to create an improved red male line uniform for color was included in the report of the 2014 season that was

distributed to seed companies January of 2015. Mutschler will produce a similar report covering the results of the 2015 season for the report to be released January 2016.

g. Regular updates are given to Orange County Vegetable Growers Association board of director's members and at semi-annual membership meetings by Maire Ullrich about progress on the project. The 2014 season results of this project were presented at this meeting in January of 2015, and the project results for the 2015 season will be presented at the upcoming January or February 2016 Orange County Vegetable Growers Association board of directors and at semi-annual membership meetings. There were 75 attendees present.

h. Regarding the publication about this project, which was projected to be completed at the end of 2nd year: This publication cannot be submitted immediately after the end of 2nd year, due to the nature of the yearly cycles of onions: the storability test will not be completed until sometime in Jan of 2016, and perhaps the culinary tests/surveys for the onion grown in 2015 cannot be completed until early 2016 as well (we are still trying to get information from one more chef. However we have now completed the storability tests; we will be able to work on a publication soon, and should be able to submit the publications late spring/early summer.

Goals and Outcomes Achieved

Stabilizing bulb color in mild red male parent using PCR based selection

This activity was fully completed and very successful. As described above in more detail, a marker based on the DFR color gene was created, tested to prove its efficacy, and then used on a very large (800 bulb) population of low pungency/increased BRIX red bulbs to select only those bulbs homozygous for the red color which were used both to establish a PURE low pungency/increased BRIX red line, and also to produce seed of a dark full red mild onion hybrid for testing in year 2 of this project with 100% accuracy. As an extra value to this project, the DFR marker has been provided to seed companies, so that they can use it on other appropriate red onion populations to improve bulb color uniformity and color of the lines and the hybrids onion cultivars created using the lines. This new technology will allow seed companies to develop red varieties at an accelerated rate. Onion growers in New York are always looking for new and improved red onion varieties.

Field trials of onion hybrids, including testing feasibility of harvesting mild onions by machine vs. hand harvest

As described in more detail previously, field trials were performed in both years in one site each in Elba and Orange County. These trials were successfully completed in both years. The Orange county trial in 2014, at a location using organic style production, weeds were a major issue, resulting in somewhat smaller bulbs than those grown at the commercial style grower's location in Elba in 2014. But overall the results demonstrated that the novel yellow, pink and red milder/higher Brix hybrids produced a very high (>90% percentage of large or Jumbo bulbs) with some entries having a very high percentage of jumbos, as demanded of mild onions.

The test of machine vs. hand harvest in the Elba location in both 2014 and 2015 showed that there were no differences in harvest method on appearance of cull or damaged onions. This is one form of data indicating that the new hybrids being tested can be machine harvested without significant negative impacts.

Testing relative pungency and sugar content of bulbs as determined by laboratory assays

This body of work was successfully completed, as shown in the section above and Tables 4, 5, 6. As predicted, the pungency assays demonstrated that the pungency level of the new yellow and pink hybrids tested was relatively low, though perhaps not as low as southern mild onions. But the new hybrids tested in the trials combined higher BRIX with the low pungency, which is a combination not found in mild onions currently on the market. The pungency level of the newest hybrid (red) was higher than the others, but still lower than pungent storage onions. Additional work would be needed to generate a lower red onion line and hybrids.

Determining relative storability of hybrids, by percentage lost/maintained in storage

This body of work was successfully completed, as shown in the section above and Tables 7, 8. Storability of the new yellow and pink hybrids tested were very high, which is consistent with predictions of the onions having moderate storability (unlike most standard mild onions which have short storability). Storability is an extremely valuable trait, as it provides the grower a longer period to hold/sell his crop, timing his sales to when prices are highest. Furthermore, harvest method did NOT affect storability of the bulbs. This provides another indication that the low pungency/increased BRIX novel hybrids are sufficiently firm to allow the use of machine harvest. This would greatly reduce production cost and allow for growth of larger area of this type of mild onion, without the added cost hand harvest entails.

Testing cooking quality of onions, through evaluation by executive chefs

This work is almost complete, we are trying to get the feedback from the last chef. Once we get that last report, we will have reports from executive chefs in full service restaurants, institutional restaurants (Cornell Dining), commercial food preparation (Wegman's) vegetable sales (Wegman's) as well as vegetable processors (Amy's kitchen).

Wide distribution of results, bridging seed companies, growers, marketers.

As listed above, the results have been released through multiple channels, in presentation and reports, to onion growing community, onion council, and seed companies. We have also interacted with marketers of onions (groceries, processing companies) to acquaint them with the possible new product, and so help build demand by marketers, processing companies and consumers for the new onions.

Beneficiaries

The onion industry in NYS, and similar climatic regions in neighboring states, is the target beneficiary here. Benefits will be realized as growers adopt and profit from the production of mild onion varieties. However onion marketers, processing companies which use onions, and consumers are downstream beneficiaries. The onion seed producing seed companies are also beneficiaries, since they can use the improved lines, the marker developed, and can also use the information that development of mild/higher brix long day onion is possible, and the potential benefits of such onions for seed sales.

According to the 2012 USDA Ag Census, 278 farms harvested 7,958 acres of onions in NYS in 2012 for a total production value of $35.0 million. According to the USDA Agricultural Statistics Service in 2014, 8,000 acres of onions were harvested in NYS and the value of production totaled $33.8 million.

It is difficult to estimate the number of onion growers impacted in NYS, as this number has been in flux in the past few years. All/any current or future onion growers to have/are growing pungent onions would already have the experience and facilities necessary to expand and also produce mild onions adapted to NYS, particularly ones, like those in this project, which due to increased BRIX withstand machine harvesting and have at least mild stability. Furthermore, these growers would

benefit from reduced labor cost (as a result of machine rather than hand harvest, and reduced risk of loss if migrant labor becomes less available at harvest time. With manual labor being a major cost of onion production, this saving could significantly help growers remain financially viable, and improve their profitability.

All onion markers/sellers who handle this type of onions would benefit from enhanced storability/reduction of loss in storage.

Lessons Learned

- **Onions combining mildness and increased BRIX have potential for NYS.** The novel yellow hybrids performed particularly well, for ability to withstand machine harvest without loss of yield or storability, and are consistent for increased BRIX and reduced pungency. The pink hybrids tested were also low in pungency, but not as low as the two yellows tested, and tended to be the highest in BRIX. Comments by some growers were quite favorable, and one canning/processing company testing the two yellow hybrids in 2015 has requested seed for additional trials as they are considering using one of them.
- **Benefits of doubled haploids.** The novel yellow hybrids performed particularly well, for uniformity of bulb size and shape, and maturity. The pink hybrids were less uniform in bulb size and shape, although were equivalent to commercial hybrids in these considerations. The high degree of uniformity of the yellow is attributable to the fact that the yellow male lines were developed through doubled haploid technology, which generates pure and entirely inbred lines. This project also demonstrates that onion breeding programs (either Seed Company or public) could benefit from use of doubled haploid technology, not only for uniformity of bulb confirmation, but also to handle for more complex traits, such as pungency.
- **Need for quality transplants grown in NYS:** Transplants are used to maximize size in mild or red onions. However most transplants are grown in the south, which can be a conduit for transport of insects and diseases. This project used commercial plug transplants. Improvements in NYS production of high quality transplants could be an important factor to improve for growth or either mild or pungent jumbo sized onions in the state. The quality of the transplants grown locally were not as good as desired in terms of size and vigor. Furthermore plug production is expensive, so to counter this, plants are grown 3 to a plug. However, since onions do not compete well, even with other onions, having 3 plant per plug increases competition, which would reduce bulb size. Perhaps, if costs of production are reduced by use of machine harvest, mild onion transplants could be grown with one vigorous plant per plug to resolve the issue of competition.
- **Is direct seeding possible for production of large/jumbo bulbs?** This project did not include direct sowing of entries, do to limitations in seed and other resources. Therefore we focused on transplants. Transplants tend to be used for the mild or red onion production, since their markets demand large or jumbo size, and spacing of the onion plants is critical to attain uniformly very large/jumbo bulb size. However reliable availability of high quality vigorous transplants is not as good as needed for transplants grown in the south, and even less for transplants grown within the state. This is an area that would benefit from applied research. The alternative to using transplants would be precision seeding of seed with reliable extremely high germinability, and/or use of precision thinning after germination. However this could be extremely costly, and hard to achieve.

- **Marketers/chefs do not always agree on traits**. Representatives from one Seed Company felt that mild onions from NYS must be of the flattened globe shape characteristic of mild onions from the southern US, saying that the flattened globe is what marketers and consumers "expect" of a mild onion. However chefs praised the round or tall round shape of the mild hybrids tested in this project as being superior for cutting and resulting in less waste than the typical flattened globe of the standard mile onion. Difference in appearance could also be an advantage for branding/marketing Northern locally grown mild onions.
- **There might be fewer uses for colored onions, but there still considerable interest in them**: Red onions are generally not used in "wet" cooking, since the red pigment is water soluble, and so leaches out during cooking in the presence of water. However red onions can add color to salads/cold foods as well as pickling and grilling, since they do not lose color when grilled or in some pickling applications. Therefore the market for red onions has been increasing. Some of the chefs were quite interested in the possibility of a red mild onion for grilling and salad/raw uses to add color. They were less interested in the pink color, just for the sake of color alone, but they liked the pink hybrid for its flavor, which they indicated was similar to shallots. For commercial food preparation, use of a large mild pink with a flavor profile similar to shallots would have distinct advantages; substituting the pink onion for shallots reducing labor of peeling and chopping to about 25% of that of a similar final volume of shallot bulbs.

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Project 3 (FINAL)
Expanding the Green Industry Palette: Improving Nursery Native Tree Production to Increase Profitability

Project Summary

Landscape trees are subjected to a multitude of stress factors at transplanting. Included in these factors is a reduced root volume that severely limits the tree's ability to recover after transplanting. Several tree species overcome this period of stress with few problems. Not surprisingly, these species have become the staples of the nursery and landscape industries. New York's nursery industry has achieved recognition both regionally and nationally, but increasing consumer desire for native tree species is a trend that has the potential to significantly increase nursery profitability. Moreover, national sustainability rating schemes such as LEED (Leadership in Economic and Environmental Design) and Sustainable Sites Initiative reward developments where landscapes use appropriate native species. Recently, New York City Mayor Michael Bloomberg signed a directive requiring the parks department to plants more native trees. Clearly the demand for native trees is going to grow.

There are clear benefits to growing native trees including an extended tree selection for growers and promoting ecological benefits such as environment adaptability including cold hardiness and support of native wildlife habitat. Unfortunately, there are many highly desirable native trees that are currently uncommon in the nursery and landscape trade often because of difficulty in transplant success. This project aimed to determine the factors influencing transplant success of native tree species, including transplant timing and tree transplant size. We studied six native tree species with three different calipers. The species are common to urban landscapes. We monitored tree root characteristics for two years after transplanting the trees in two different seasons (spring vs. fall), including root hydraulic conductance and root regrowth rate, to understand the physiological mechanisms behind transplant shock. A full assessment of post-transplant growth was also conducted. Recommendations of improving tree transplant success have been made based on the results for the nursery industry.

Project Approach

Six tree species with three different calipers (Table 1) were obtained from Schichtel's Nursery in Springville, NY and bare-root transplanted at Bluegrass Lane research field in Ithaca, NY in late April 2014 and early November 2015, respectively. Tree root balls were pruned after digging out in the nursery and wrapped with a large plastic bag during transport from Springville to Ithaca. All the transplanted trees are growing together in an Arkport sandy loam at Bluegrass Lane research field. The location of each tree in the field was randomly assigned. The trees are watered weekly with 20 liters of water starting immediately after transplanting. Meanwhile, the trees growing in the nursery without root pruning were treated as controls.

Our preliminary study has shown that trees surviving better after transplanting were able to maintain higher specific hydraulic conductance (K_S) in fine roots (~ 1.5 – 2 mm in diameter) after transplanting, or their fine root K_S increased faster to the control level after transplanting. In order to quantify the impacts of transplanting on post-transplant recovery of six tree species, fine root K_S was measured using a Gen 3 hydraulic conductance flow meter (HCFM, Dynamax Inc., Houston, TX, USA) immediately before transplanting for all the transplanted trees, and be monitored every two months afterwards as well. Fine root K_S was also measured on control trees grown in Schichtel's Nursery every other month during the growing seasons of 2014 and 2015.

Tree post-transplant recovery was assessed by measuring the diameter at breast height (DBH), average leaf area, leaf photosynthetic rate and new shoot extension on both control and transplanted trees. DBH, leaf area and new shoot extension were measured bimonthly during the growing seasons of 2014 and 2015. Leaf photosynthetic rate was measured every month on transplanted trees. For control trees, leaf photosynthetic rate was only measured in September of 2014 and 2015.

Meanwhile, soil ingrowth cores were installed to estimate fine root regeneration. The cores were made with plastic canvas (6.75" × 4.75"). When installed, one end of the core was covered by a plastic lid, and the other end was connected to the root pruned surface. For transplanted trees, three cores were installed for each tree. One core was sampled from each tree every other month during the growing season. For control trees, in order to avoid large disturbance to soil environment, only one core was installed for each tree. When sampling fine roots from control trees in May of each year, a core was installed right next to the sampled root. The control soil cores were sampled at the end of each growing season.

After one growing season, all spring-transplanted trees survived transplanting except *Quercus macrocarpa* (QM) of 2 ½ inches, and most of the fall-transplanted trees survived transplanting as well with the exception of *Gymnocladus dioicus* (GD), 1 ¼-inch *Quercus cocinea* (QC) and 2-inch *Quercus bicolor* (QB). Trees that did not survive transplanting showed severe "transplant shock"; root K_S and leaf photosynthesis also dropped to near zero. Usually, GD and QB are thought to be the easily-transplanted species, while the other four species used in our project are difficult to transplant. Surprisingly, fall-transplanted GD and QB did not recover well after transplanting. GD trees may have had frost injury; surprisingly, even the control GD trees did not have new leaves until July 2015, and the leaves were much smaller than 2014.

Although most of the spring- and fall-transplanted trees survived transplanting, their growth did not fully recover compared to the control trees after one growing season. However, during the second growing season, the growth of spring-transplanted trees dramatically increased, including the an increase in fine root K_S, DBH, shoot extension, leaf area and photosynthesis, with the exception of 1 ¾-inch QM trees which died during the second year after transplanting. The second year of growth for fall-transplanted trees will be determined in 2016.

Our research/extension group is comprised of two faculty, a postdoctoral associate and research support specialist in the Section of Horticulture, Cornell University, and the staff at Schichtel's Nursery in Springville, NY. PI Dr. Bauerle is a Plant Physiologist with special expertise in plant growth strategies and root eco-physiology. Co-PI Dr. Bassuk focuses on tree selection and cultural practices to optimize tree growth and production particularly as it applies to urban environments. Drs. Bauerle and Bassuk co-supervised the postdoctoral associate and research support specialist to conduct the treatment application and data collection. In addition, Dr. Bassuk determined the impacts of the new transplant recommendations on costs of production. The manager, Jim Kisker, provided significant support and contributions to this project in terms of sampling on control trees and transporting transplanted trees from the nursery to Ithaca, NY.

Goals and Outcomes Achieved

The goals of this project included: 1) examining the impact of transplant timing and tree transplant size on transplant success; 2) examining the physiological mechanisms behind transplant shock; 3) conducting outreach to the NY state green industry, so that at project end at least five NY nursery growers experiment with one of the transplant success practices.

In order to achieve the first goal, we transplanted six tree species from Springville to Ithaca in early spring and late fall, respectively. There were three different caliper sizes for each species, small-, mid- and larger-caliper. We observed that fall-transplanting is preferable for most of the species, indicated by higher shoot extension and leaf area in the first year after transplanting, especially in *Carpinus caroliniana* (CC), *Nyssa sylvatica* (NS) and QM (Figure 1). For both spring- and fall-transplanted trees, in general, small- and mid-caliper trees recovered better than larger-caliper trees after root pruning and transplanting. There was marginal differences in post-transplant recovery between small- and mid-caliper trees for most species. We also examined the second year growth after transplanting for spring-transplanted trees. These data showed that the second year growth increment was significantly larger than the first year in terms of higher fine root K_S, longer shoot extension and larger leaf area for the second year compared to the first year (Figure 2).

In order to achieve the second goal, we measured root hydraulic properties (fine root K_S), leaf physiology (net photosynthetic rate) and year growth (shoot extension) across all the species, and conducted correlations between them at the end of the growing season (Figure 3). The positive correlations indicate that fine root K_S is related to post-transplant recovery of the species. In other words, species that are able to maintain higher fine root K_S or to increase fine root K_S faster after transplanting recover better after transplanting.

The results from the first two goals suggested that maintaining higher root hydraulic conductance during transplanting is critical for increasing transplant success rate, which could help the nursery industry to develop better practices across production method including bare-root, balled and burlapped, container grown, etc.

PI Bauerle and Co-PI Bassuk successful determined the differences in transplant success between three native and one non-native, difficult to transplant species and non-native easy to transplant species. While production costs at the individual tree level did not differ the PI's were able to provide recommendations based on transplant timing and tree size that would increase the success rate of native trees in the landscape. Project leaders disseminated recommendations based of results found within the *Expanding the Green Industry Palette: Improving Nursery Native Tree Production to Increase Profitability* report to over 100 growers and green industry professionals. We are currently preparing a peer-reviewed article for publication.

Presentations:

Cornell University In-service training for Extension Educators. "Woody Plant Selection and Establishment in the Landscape". November 4, 2015. (50 participants)

ISA Arborists training, "Urban Soils and Transplanting" Hudson Valley March 2015 (60 participants)

Master Gardener Webinar Training "Woody Plants" May 12 2015. (60 participants)

TREE Fund webinar. "Strategies for Successful Urban Tree Growth in Wet and Dry Sites." September 23rd, 2015. (200 participants)

Urban Forestry Today, University of Massachusetts, Webcast Series. Roots, trees, and the urban environment: a continuing discussion. (150 participants)

Trade article:

Sutton, M (with N. Bassuk) July, 2014 "Oaks, Bubbles and Scoop-and-Dump: Interesting Research Continues Apace at the Urban Horticulture Institute" *City Trees Vol. 50 No. 4* pp 10-14

To our knowledge an estimated greater than 1,000 acres benefited from this project with nursery trees spread over approximately 20 farms. Estimated financial benefit to farmers is upwards of $50 per tree. There is the potential that these numbers could be greater however some modes of project dissemination were over webinars where it can be difficult to gauge the full identity of the audience that logs onto the webinar.

Beneficiaries

This project aimed to improve marketing potential for nurseries through the diversification of marketable tree species. According to New York State Agriculture and Markets, New York State has 1905 nurseries or combined nurseries and greenhouses which represents the potential number of beneficiaries of this project.

The continued growth of local nursery industry is dependent on consistently producing high-quality premium stock that follows current consumer demand and is available at competitive prices. Our project showed that fall-transplanting is preferable for most of the studied species compared to spring-transplanting. Moreover, smaller-caliper trees generally recover better than larger-caliper trees. This study also revealed the physiological mechanisms behind “transplant shock”.

By better understanding the physiological basis of root behavior during transplanting, better nursery practices can be developed to reduce transplant shock and increase transplant success rate. For example, for bare-root production we should aim to maintain root hydraulic conductance by maintaining a high moisture environment around roots. Bare-root plants could be held in cool storage with their roots packed in damp materials during transportation; or the roots could be surrounded by organic matter such as biochar which is well known for its high water retention capacity. Developing better practices will have a direct impact on the economic and environmental sustainability of the nursery industry.

In the last comprehensive survey of economic impacts of the US green industry, (2002) the green industry in New York ranked 6th in the nation. Looking at nursery producers alone, the value of NYS nursery products was over $5,000,000 annually and employed over 65,000 jobs. Markets for nursery products are most heavily located in urban areas where demand for trees and shrubs is greatest.

With the national emphasis on native and well adapted trees for urban areas, certain desirable species have difficulty being produced due to tree failure after transplanting. Even with easily transplanted trees, transplanting success ranges between 80-90%. With more desirable, well adapted and native trees, transplanting success is often 30-50%, a considerable loss for the grower, contractor and ultimately the landscape.

Given the difficulty in transplanting these trees, growers are not growing them as much even though there is high demand. Improved transplanting techniques would impact every tree grower in New York State. By developing more reliable transplanting procedures, growers would benefit from greater sales and client satisfaction.

Lessons Learned

Previous studies have indicated that tree transplant size may affect transplant success. Although larger-caliper trees are often more desired for an immediately mature landscape, it was often found that larger-caliper trees have a slower growth rate than smaller-caliper trees. In this project, we used three caliper sizes, small-, mid- and larger-caliper, but the differences in post-transplant recovery between small- and mid-caliper trees were marginal. In future studies, we will enlarge the size difference between small- and mid-caliper trees to obtain a better understanding of the effect of transplant size on transplant success.

We observed that fall-transplanting is preferable to most of the studied species compared to spring-transplanting. However, only one of the four small-caliper *Quercus coccinea* (QC) trees survived fall-transplanting, while all of the mid- and larger-caliper QC trees survived. This is unexpected, and probably is related to the severe winter frost this year. *Gymnocladus dioicus* (GD) trees may also have had frost injury over the winter 2015; neither control nor transplanted GD trees had new leaves in June, and none of the transplanted GD trees grew new leaves after fall-transplanting. So we would suggest that fall-transplanting could be carried out a little earlier during the fall season.

When we were transplanting the trees at the Bluegrass Lane research field in Ithaca, NY, the holes dug by the auger were very deep, which brought a lot of difficulties in sampling the roots from transplanted trees later on. So we would suggest that shallower holes could be made when doing transplanting studies on tree roots in the future.

In June 2015, fine roots and leaves were not sampled from mid-caliper control trees except for *Carpinus caroliniana* (CC) because there was a severe storm in Springville on that sampling day. Only small- and large-caliper control trees were sampled on that sampling day.

Additional Information

Table 1. List of six tree species studied in this project.

Species	Caliper size		
	Smaller	Mid	Large
Carpinus caroliniana	1”	1 ½”	2”
Gymnocladus dioicus	1 ¼”	1 ½”	2”
Nyssa sylvatica	1”	1 ½”	2”
Quercus bicolor	1 ¼”	1 ¾”	2”
Quercus coccinea	1 ¼”	1 ¾”	2”
Quercus macrocarpa	1 ¼”	1 ¾”	2 ½”

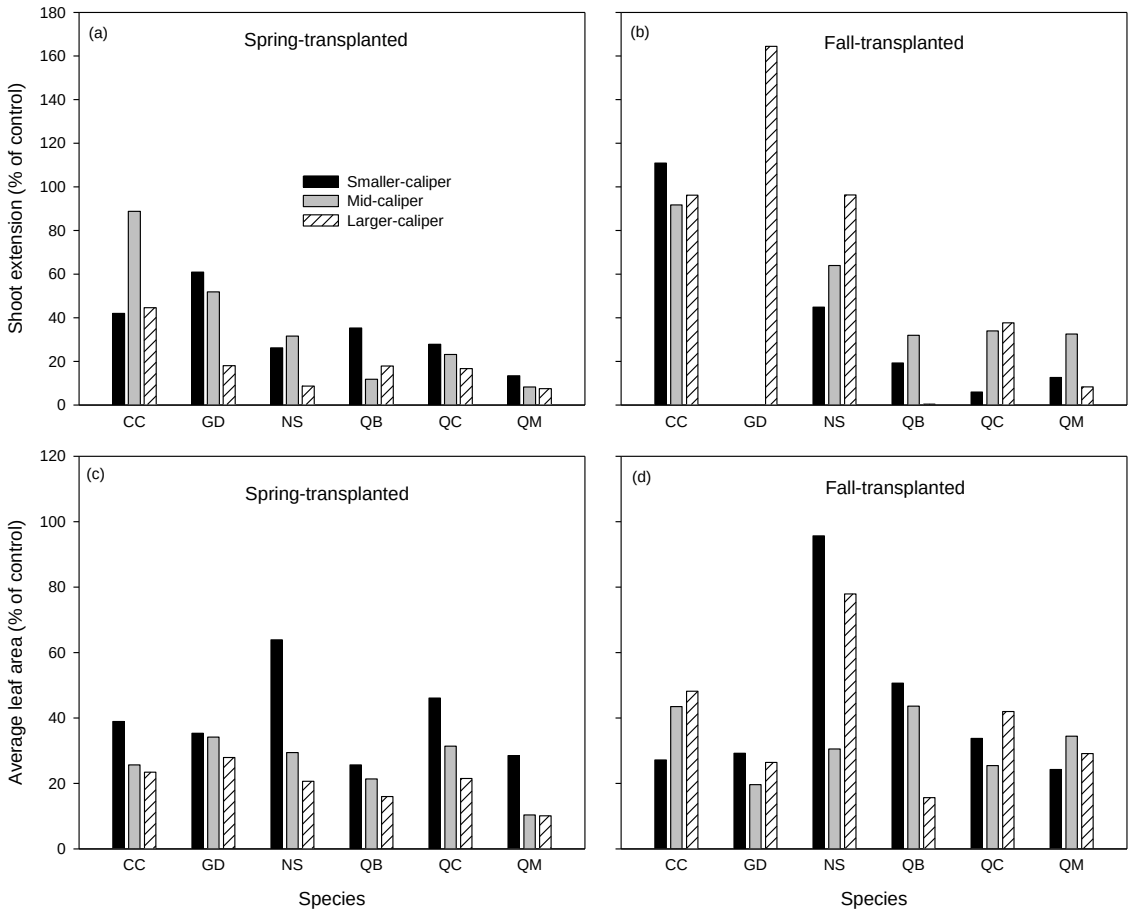

Figure 1. New shoot extension (a and b) and average leaf area (c and d) of spring- (a and c) and fall-transplanted (b and d) trees in three different calipers, presented in the percentage of controls. Both shoot extension and leaf area were measured at the end of the growing season. Black bars represent small-caliper trees; gray bars represent mid-caliper trees, and hatched bars represent larger-caliper trees. The measurement was conducted on six species: *Carpinus caroliniana* (CC), *Gymnocladus dioicus* (GD), *Nyssa sylvatica* (NS), *Quercus bicolor* (QB), *Quercus coccinea* (QC) and *Quercus macrocarpa* (QM).

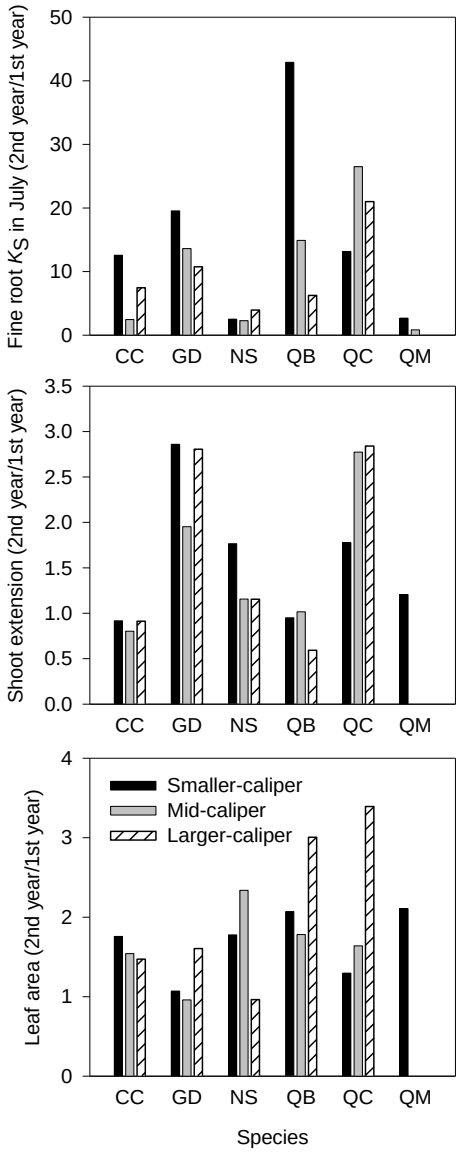

Figure 2. The comparisons of growth (fine root specific hydraulic conductance, shoot extension and leaf area) between the first year and second year after transplanting in six species: *Carpinus caroliniana* (CC), *Gymnocladus dioicus* (GD), *Nyssa sylvatica* (NS), *Quercus bicolor* (QB), *Quercus coccinea* (QC) and *Quercus macrocarpa* (QM). If the ratio is larger than 1, it means the second year of growth is larger than the first year.

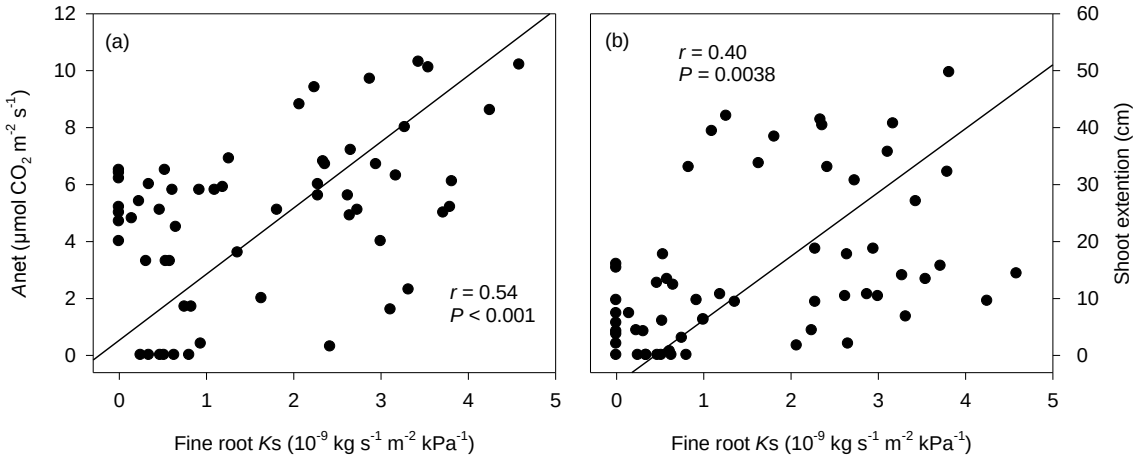

Figure 3. The correlations between fine root specific hydraulic conductance (K_S) with net photosynthetic rate (A_{net}, a) and shoot extension (b). The measurement was taken at the end of the growing season in 2015.

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Project 4 (FINAL)
Enhancing Foundation Potato Seed Production for NY State by Establishing a Hydroponic (Aeroponic) Production System at the Uihlein Farm of Cornell University in Lake Placid, NY

Project Summary

NY State potato growers purchase seed potatoes that originate from seed produced at the Uihlein Farm of Cornell University in Lake Placid, NY. The specific problem is that there are two rate-limiting steps in this process of producing Foundation seed potatoes: i) the timing and scale of the in vitro propagation of disease-tested mother plants of each potato variety (e.g. the plant tissue culture work conducted in the laboratory), and ii) greenhouse space for the production of the minitubers. This project has addressed the latter space limitation by implementing a technological design to improve the efficiency of production.

A rate-limiting bottleneck in Foundation seed potato production is greenhouse space for and the efficiency of growing minitubers. Those who benefitted from the project were the seven private NY seed potato growers and commercial potato growers in NY and 9 other States who purchase seed directly from the Uihlein Farm. The Farm was better able to deliver the needed quantities of requested varieties.

Project Approach

Project personnel met with project partners and New York potato seed growers in 2014 and 2015. Four full-bench hydroponics chambers were constructed and put into operation for production in both project years. Producing the potato plant material for planting in the aeroponics chambers required the propagation of tissue culture plants for four separate crops; a crop corresponds to the collection of 10 to 17 different potato varieties grown in the aeroponics chamber over the same three to four month period. The four crops were managed and minitubers from each crop were continuously harvested. For comparison, production of the same potato varieties was carried out in parallel.

The primary role of the project partners was in providing input on the selection of potato varieties that were chosen for production in the aeroponics chambers. The varieties we produced were in response to grower demand.

Goals and Outcomes Achieved

The outcome measures are long term in the sense that the project goal was to enhance foundation potato seed production for NY State and this is an ongoing process. We are doing this by constructing and implementing the use of hydroponic (aeroponic, nutrient film technology) potato growth units and increasing the production capacity of the Farm. The implementation is ongoing and improvements in production practices are continuing.

The goal of this project was (is) *to better serve northeast potato and vegetable growers by providing them quicker or earlier access to potato varieties they order. This will be made possible by doubling the minituber production at the Cornell Uihlein Farm.* We measured the minituber production in aeroponics chambers versus greenhouse pots for 28 potato varieties. Increased productivity was observed for 20 of the varieties, in at least one of the two seasons monitored. Doubling the production was only observed in the cases of the varieties Lehigh and Adirondack Red.

There were three set targets. The first was *to convert 6 glasshouse benches to hydroponic production and double annual minituber production*. Four glasshouse benches were converted to four

full-size bench chambers; not all potato varieties grew well in the chambers and logistically we could only produce the necessary plantlets to grow in four chambers. Presently, four chambers is the carrying capacity of the farm and six would be counterproductive.

The second target was *to increase the number of growers served*. The number of growers served has been relatively consistent, with 21 growers in 2013 and 20 growers in 2014.

The third target was *to increase a combination of the number and quantity of cyst nematode resistant varieties delivered to a greater number of growers*. This third target was not reached, as there was very limited change in the number and quantity of varieties from the 2012/2013 to the 2014/2015 growing seasons; the numbers of varieties ranged from 19 to 21 and the quantities ordered by growers ranged from 3,891 to 4,617 cwt.

We were not able to shorten the time within the project period. This project addressed the development of a technology for minituber production and at the end of this project funding period, this production system was established. The time frame for delivery of seed potatoes to a grower is a 4 or 5 year cycle , i.e. Year 1, minituber production -> Year 2, - first year of field production -> Year 3 –second year of field production -> Year 4 –third year of field production, Year 5 –delivery to growers. Thus the impact on shortening the time is not yet apparent.

Beneficiaries

Those who most immediately benefited from the project are the seven private NY seed potato growers and commercial potato growers in NY and 9 from other states who purchased seed directly from the Uihlein Farm. Ultimately, it will be the potato seed producers, commercial tablestock growers, chipstock producers, and diversified small-scale vegetable farming operations, who in subsequent years will receive seed grown from the Foundation seed produced at the Uihlein Farm in 2012-2015.

Using the 2014 crop as the reference, we produced 35,692 useable minitubers, up from 34,344 in 2013; this represents a modest 4% increase. The 14 participating NY growers received a total of 3,505 cwt of seed potatoes.

Lessons Learned

We have learned that the two limiting factors in producing minitubers aeroponically in growth chambers are: i) the levels of fertilizer provided in the nutrient solution, and ii) the length of the cropping period. By optimizing the nutrient levels and reorganizing the greenhouse operation to extend the cropping period by ~4 weeks, we expect to be able to more than double the production of minitubers for potato varieties amenable to aeroponic growth. These changes will be launched next February/March with the planting of the first crop of 2016.

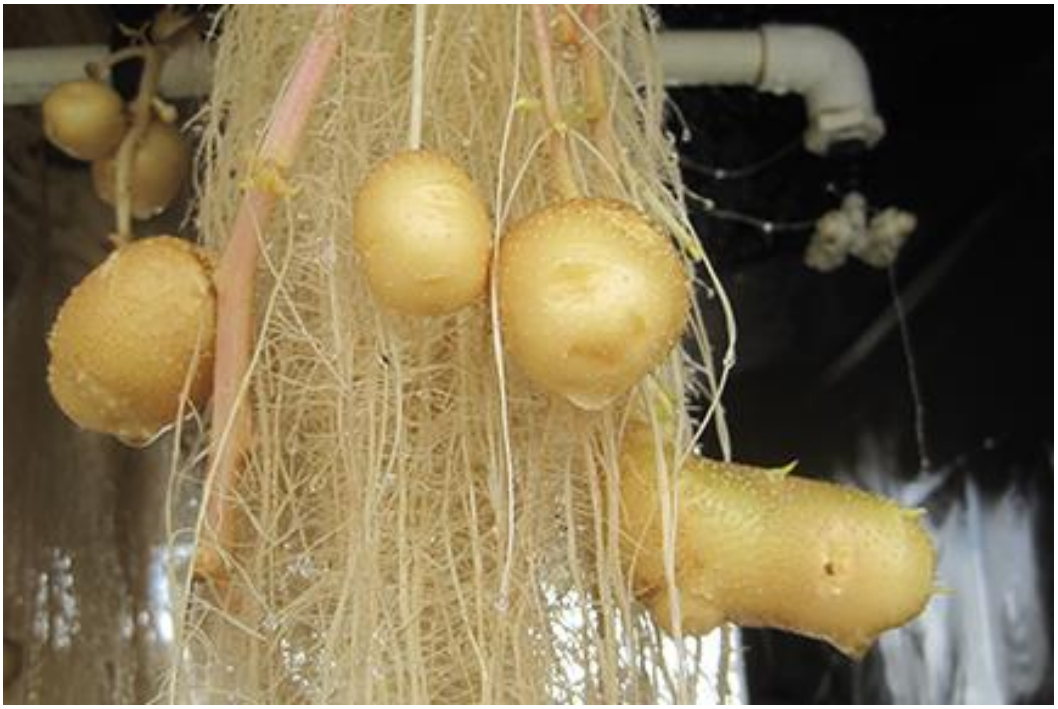
While the minituber production in aeroponic chambers of some potato varieties can be easily doubled relative to growth in pots, not all potato varieties grew well in the chambers. Thus, for those challenging varieties, we will maintain all production in pots and focus the use of the chambers for the production of select varieties.

Shifting a production system to a newer technology cannot necessarily be accomplished in a projected time frame when unforeseen variables arise. In the case of this project, recognizing that the new technology was not effective for some potato varieties required a shift in planning. The plant tissue culture preparations for the crop planted in February begins the preceding September. The tissue

culture operation could not adapt quick enough to produce sufficient plantlets to plant six full size chambers, necessitating scaling back the project. Achieving the objective of production in aeroponic chambers required investing more effort in the tissue culture component of the operation.

Additional Information

Below are photos of the aeroponic chambers and the minituber production made possible by this grant.



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Project 5 (FINAL)

Developing Methods to Eliminate the Crown Gall Pathogen from Grapevine Propagation Material to Strengthen New York's Viticulture and Nursery Industry

Project Summary

Crown gall is a limiting factor to the grape industry in NY. The NY wine industry continues to expand with over 400 wineries that contribute over $4 billion annually to the State economy. It is more urgent than ever to be able to develop and maintain vines that are free of the crown gall pathogen. Fortunately, we have made excellent progress in crown gall management and information from this grant has furthered our ability to control this disease. We initially received funding from USDA APHIS that was used to develop the first sensitive indexing method for crown gall. The SCBG reported here has allowed further development and comparisons of indexing methods, the development and testing of methods for eradication of the bacterium from propagation material and also determination of environmental sources of the crown gall pathogen that will impact disease management.

This research was motivated by the needs of the NY grape industry. Crown gall is a serious problem that is enhanced following freeze injuries to vines. With a changing, unpredictable climate, freeze events seem to be more regular and add to the severity of this disease. Also, the economic value of the grape and wine industry to NY is also growing. There is a great need to produce and plant vines that are free of pathogens that cause crown gall. Therefore, this work is very timely and important to the future of the NY viticulture and nursery industries.

This is the first SCBG that funded this research. However, as mentioned above the work was built on research funded by USDA-APHIS through the National Clean Plant Network.

Project Approach

Procedures were compared to determine that which would be most effective for detecting the crown gall pathogen in grapevines. This was done using several strains of the pathogen and using different samples of grapevines collected from collaborative partners. A highly sensitive method was evaluated, which is now being used routinely for evaluating the presence of the pathogen in grapevines and other environmental sources.

It was determined that submersing dormant grape cuttings in a water bath at 50^{o}C for 60 minutes significantly reduced the number of *A. vitis* positive cuttings. Without treatment, 12 of the 26 vines tested positive for the crown gall pathogen. After treatment, 5 of the 26 vines tested positive, thereby representing a 58% reduction in cuttings with *A. vitis*. Therefore, this heat treatment significantly reduced the incidence, but did not eliminate the pathogen from dormant cuttings.

The use of shoot tip and meristem propagation were evaluated as a means of producing grapevines that are free of the crown gall pathogen. Thus far, all indications are that clean plants can be produced. This work will continue to verify that plants remain clean and also to measure possible contamination of plants that are planted into field environments.

Sources of the crown gall pathogen in the environment were also determined. This work is also continuing; however, at this point we have determined conclusively that wild grapevines can harbor the pathogen. This is very significant considering how ubiquitous wild grapevines are in viticultural areas of NY State.

Specifically the following was conducted as part of this project:

- The utility of a highly sensitive method for detecting the crown gall pathogen in grapevines and in other environmental sources was established.
- The ability of wild grapevines to serve as a source of the pathogen was established.
- Overwintering of the crown gall pathogen in dormant grape buds was also determined as was its ability to be detected on surfaces of grape leaves during the growing season.
- Significant progress was also made on the production of vines that are free of the crown gall pathogen through tissue culture.

Project partners were instrumental in facilitating this research. We made several visits to cooperating partners who provided grape material and use of their vineyards that were critical for doing the research.

Goals and Outcomes Achieved

Objective 1

The first objective of this project was to compare methods for detection of the crown gall pathogen, Agrobacterium vitis, in grapevines. In this case, we compared a method based on Taqman technology to a method we recently developed based on Magnetic Capture Hybridization (MCH).

For MCH and Taqman procedures, we relied on detection of sequence of a specific gene, virD2, which is required by the pathogen for crown gall to form. Specific sequences of the gene that are conserved across many strains of the pathogen are the target for both of these assays. To meet this objective, several strains from different geographic regions were compared and then samples of cuttings taken from crown gall diseased vines were compared with both methods.

The results indicated that both methods were equally effective for detection of all of 52 strains of the crown gall pathogen collected from diverse geographic regions worldwide. However, when the methods were compared on cuttings taken from crown gall, infected fines the MCH method was superior over the Taqman method. For MCH, the pathogen was detected in 17 or 22 samples; whereas for the Taqman method, the pathogen was detected in only 10 of the same 22 samples.

We hypothesize that the Taqman method may be too sensitive for this routine analysis of grape cuttings collected from commercial vineyards. Strains of the pathogen in nature are likely to have slight sequence differences in their virD2 gene and if they do not precisely match up with the Taqman probe they will not be detected whereas the MCH method is more forgiving to slight sequence variability. For this reason, and because MCH is less expensive to run than Taqman, we decided to use the MCH method for indexing grape propagation material for the presence of the pathogen. This method was also used to help address other goals in this project.

Objective 2

The second objective of the grant involved determining the effectiveness of procedures for eradicating the crown gall pathogen from propagation material. Because the crown gall pathogen is randomly distributed within vines and in grape propagation material we wanted to determine if heat treatment of dormant cuttings is a viable treatment for eradication of *A. vitis* from contaminated vines. In previous studies we did not have access to the MCH method for detecting the pathogen in grape

cuttings. Dormant canes were collected from grapevines infected with crown gall in commercial vineyards in New York. Canes were cut into three node cuttings and two canes from each vine were used in the assay. One section was assayed immediately for *A. vitis* while the second section was assayed after heat treatment. The treatment included submersing cuttings in a water bath at 50^{o}C for 60 minutes. After heat treatment, the cuttings were assayed for *A. vitis*.

We determined that submersing the dormant cuttings at 50^{o}C for 60 minutes significantly reduced the number of *A. vitis* positive cuttings. Without treatment, 12 of the 26 vines tested positive for the crown gall pathogen; whereas after treatment 5 of the 26 vines tested positive, representing a 58% reduction in cuttings with *A. vitis*. Therefore, our results verified that while heat treatment significantly reduces the incidence, it does not eliminate the pathogen from dormant cuttings.

Another strategy for elimination of the crown gall pathogen from grapevines that was tested in this project is to grow the vines from shoot tips or from shoot tip meristems with the intention of excluding the pathogen from the new plant. The utilization of shoot tip culture has been used in the past but was never critically evaluated employing the sensitive and specific MCH detection method. To test this strategy, shoot tips (tip of shoot and first unfolded two leaves) were collected from a commercial vineyard with crown gall and from grapevines growing in a greenhouse where crown gall was present. Experiments were initially aimed at determining whether the pathogen survives in shoot tips, in the shoot tip meristem and whether the pathogen survives on the surface of the tissues or internally. In all cases the MCH method was used to test for the presence of the pathogen.

Two replications of the greenhouse experiment were completed. In these cases the shoot tips were dissected into shoot meristem and the rest of the shoot tip. For the first replication, *A. vitis* was detected from 18 of the 29 vines. Of these, 13 vines were positive for meristems only, 3 for shoot tip minus meristem. However, in the second replication using the same vines, only 4 of the 29 samples were positive with 3 vines having positive meristems and one being positive for both meristem and shoot tip minus meristem. These results indicate that, at least for vines infected with crown gall or growing in the close proximity to crown gall, the shoot tips, including the meristems, can carry the pathogen.

These experiments were then repeated in 2015 to further determine if shoot tip and or meristem culture can be employed to produce pathogen free vines. From two replications of the experiment in 2015, none of the shoot tips or meristems were found to carry the crown gall pathogen. These results indicate that it is possible to generate “clean” plants using shoot tip culture; however, it is critical that follow-up indexing of the plants is conducted.

Objective 3

The third objective of this project involved determining sources of the crown gall pathogen in the environment with emphasis on wild grapevines. In NY, wild grapevines are primarily *Vitis riparia* and are commonly growing in viticultural regions. We employed the MCH method to assay cuttings from wild grapevines that were collected from areas near vineyards and also areas removed from vineyards, such as State parks. Assays were done on 130 wild grapevines collected in fall 2013 and 2014. Of these, 30 tested positive for the presence of the crown gall pathogen. Therefore, we determined conclusively that wild grapevines may harbor the grape crown gall pathogen and are likely to contribute to crown gall development in vineyards.

We have begun to examine other environmental sources for the pathogen as well. As we move towards the development of clean vines by tissue culture, it will be essential to know where the pathogen may survive in the environment and contribute to the threat of disease development.

Some of the outcomes will be long-term such as the implementation of clean grapevines for management of crown gall. Significant progress was made toward this goal by implementing the MCH method for detecting the pathogen, by determining that clean plants can be generated through tissue culture and identifying environmental sources of the pathogen in the environment.

Goal	Actual Accomplishment
Objective 1. Develop and implement a sensitive method for indexing grape propagation material for the crown gall pathogen, *Agrobacterium vitis*.	Compared methods for indexing grape cuttings for the crown gall pathogen and determined that the described MCH method is the method of choice for assaying grapevines for the presence of the pathogen.
Objective 2. Determine the effectiveness of procedures for eradicating *A. vitis* from grape propagation material.	Verified that hot water treatment of grape cuttings is effective for lowering populations of the pathogen but does not eradicate it. Also determined that crown gall-free plants can be generated through tissue culture but follow-up testing of the plants will be essential.
Objective 3. Determine whether *A. vitis* survives in natural environments with specific attention on wild grapevines.	Assays were done on 125 wild grapevines collected near and removed from vineyards. Of these 30 were found to be carrying the crown gall pathogen. Therefore it was determined that wild grapevines can serve as a significant source of the crown gall pathogen.

Beneficiaries

The groups and operations that have benefitted and will continue to benefit from this project are those involved in the grape and wine industry of NY. This includes nursery businesses as well as vineyard operations. It is critical for them to be have access to the tools for indexing grapevines and understand the biology behind producing clean plants and managing them in vineyards to minimize the development of crown gall.

Quantitative data that concerns the beneficiaries includes:

- A method was implemented in this project that is capable of detecting as few as 10 cells of the crown gall pathogen in a grapevine sample.
- It was also demonstrated that plants that are free of the crown gall pathogen can be produced through tissue culture.
- Wild grapevines can serve as a source of the crown gall pathogen in the environment. 125 vines were assayed and 30 were found to be positive for the pathogen.

The estimated economic loss from crown gall in vineyards ranges from about $2,600 to nearly $17,000 per acre depending on disease severity and the age of vines when they became infected. Research accomplished under this project will greatly impact these losses by allowing for production of

clean vines and for effectively indexing of vines and by improving our understanding of sources of the pathogen in the environment.

The information generated from this project was delivered to grower audiences at the following meetings in 2015 and 2016:

- NY Lake Erie Grape Growers Conference, March, 2015, audience estimate = 150
- NY, Finger Lakes spring grower meeting, May, 2015, audience estimate = 125
- Ohio Grape Growers Conference, March, 2015 audience estimate = 100
- UC Davis conference on grape diseases and other research, Feb, 2015, audience estimate = 75
- WA state grape growers meeting (1/20/16) audience estimate = 175
- NJ grape grower conference (2/27/16), audience estimate = 100
- Webinar that will cover applied crown gall research (3/31/16) audience estimate = 250

Publications were generated in forms useful to the grape industry:

Appellation Cornell website – Research Focus March 2012 (newsletter attached)
http://grapesandwine.cals.cornell.edu/newsletters/appellation-cornell

Cornell Viticulture and Enology Newsletter Issue 24, February

Crown Gall Newsletter (NCPN) 2015 (attached).

The project to determine the economic impact of crown gall in vineyards is currently being written up. We expect publication in summer, 2016.

Lessons Learned

The project staff continued to challenge the obtained results to verify that the methods we used were effective in drawing conclusions regarding the biology of the crown gall pathogen. This was critical in that the results will impact disease management practices that will be implemented by the NY industry.

Perhaps the most unexpected outcome was the high incidence of the crown gall pathogen in wild grapes. Previous research had concluded that wild grapes to not harbor pathogenic forms of the pathogen; however, in this project we were able to utilize a much more sensitive method that clearly revealed the presence of the pathogen.

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Project 6 (FINAL)

Expanding the Phytophthora ramorum Sample Processing: Searching for Phytophthora kernoviae, Identifying Phytophthora Specie, and Evaluating a Test Method

Project Summary

Root rot and wilt diseases caused by various *Phytophthora* species commonly cause serious economic losses during nursery production. *Phytophthora ramorum* is an exotic pathogen that first appeared in the U.S. as a killer of oaks and tanoaks in California in the mid-1990s. It has a wide host range that includes many trees and shrubs in eastern forests and in the ornamentals industry. The diseases it causes are referred to as Sudden Oak Death or Ramorum Blight. A number of institutions, departments of agriculture, forest services and USDA agencies began surveying for *Phytophthora ramorum* in 2004 when a large production nursery in southern California discovered the pathogen in its nursery stock. New York State currently funds laboratory diagnosis in support of their survey for *P. ramorum*. This pathogen is very high on the priority list of organisms that we do not want to become established in NY. More recently, we have learned about a related pathogen, *Phytophthora kernoviae*, that has not been identified in our country yet, but mimics the symptoms of *P. ramorum* and may be even more damaging.

Cornell University's Plant Disease Diagnostic Clinic (PDDC) has provided *Phytophthora ramorum* suspect sample processing for numerous state and national agencies since 2004. Processing trace forward/back events, national and observational surveys, and Farm Bill project samples triggered questions about our goals and procedures. Since we began, 3,695 suspect *P. ramorum* samples have been processed through Cornell's PDDC with very few containing the target pathogen. Many contained a *Phytophthora* species but were not identified to the species level due to time and funding limitations—yet identifying species might provide valuable information about other important *Phytophthora* species that impact nursery crops in New York State. *P. kernoviae*, in particular, should be looked for, as this pathogen was found in Europe during their *P. ramorum* surveys. Currently only the ELISA procedure is accepted for preliminary testing to the *Phytophthora* genus level by regulatory agencies, even though the ImmunoStrip® appears to offer an ideal diagnostic tool for small sample sets. The 2014 objectives for *P. ramorum* sampling added three new components:

The purpose of this project was to accomplish three objectives that were critically important for improving the protection of our New York nursery crops, home landscapes and our natural environmental systems against *Phytophthora* diseases: 1) sequencing *Phytophthora* positive samples that were not identified as *P. ramorum*, 2) testing *P. ramorum* suspect samples using real time PCR ITS1 and ITS2 protocols for *P. kernoviae*, and 3) a comparison of the ELISA *Phytophthora* species procedure with the ImmunoStrip® test.

Project Approach

Phytophthora ramorum suspect, visual symptom collection samples were submitted to the PDDC beginning in April of 2014. We received a total of 150 samples in 2014 originating from New York locations. The samples came to us as 35 symptom survey samples, 2 soil submissions, 30 water baiting leaf sets, 21 bottle of bait (BOB) samples and 62 trace forward samples. All of these samples were used in the three objectives of the project.

The technician working on this project resigned from the position on July 30, 2014 and a new technician was hired on September 15, 2014. Our original plan was to have all the objectives completed by December of 2014 but we needed to extend that out a few months through February or March of 2015. This extended timetable did not affect the completion date for the project. During the interim, the Diagnostician and Director of the PDDC processed samples associated with this project. The Director and Diagnostician were able to ensure the samples were processed on a timely basis and performed DNA extractions of those meeting the criteria for molecular testing. The new technician came to us with an extensive background in molecular techniques, which helped us get her prepared to take over the testing process very quickly. During the last two weeks of September 2014, the new technician received training on the techniques required to complete the Objective 3 activity and to perform the Objective 1 survey for *P. kernoviae*. Objective 1 was planned to start earlier in our timetable but those testing procedures were put on hold awaiting the hiring of the new technician. The new technician began the Objective 1 activities October 31, 2014 and completed them on November 24, 2014. Planning for Objective 2 began in December of 2014, the technician began researching the numerous steps to the process of sequencing the unknown species of *Phytophthora* found in the survey. She purchased the needed supplies and developed plans to begin the processing of samples in January of 2015.

None of this work would have been possible without the collaboration between the laboratory members and the New York State Department of Agriculture (NYSDAM) staff. NYSDAM staff conducted all of the field work associated with collecting samples and providing sample data such as location, plant species, sample type, etc.

Objective 1: Survey for *Phytophthora kernoviae* in *P. ramorum* samples.

P. kernoviae is now found in Europe and causes similar symptoms to *P. ramorum*—but apparently much worse damage. It is important to realize that *P. kernoviae* was found in Europe during their *P. ramorum* surveys.

Objective 2: Determine the *Phytophthora* species present in samples that contain a *Phytophthora* other than the target species (*P. ramorum*).

To date, the Cornell PDDC has processed 3,056 suspect *P. ramorum* samples with only a very small number identified as *P. ramorum*. Hundreds, maybe even thousands, of samples have contained other *Phytophthora* species that have not been identified because they were not the target of the survey and time and funding were limited, but this has meant that important information about these pathogens and their potential impact on nursery crops has not been captured. These other *Phytophthora* species commonly cause significant diseases in New York nurseries, but there has never been an opportunity to survey their diversity and learn about their distribution. We now have such an opportunity because we can capitalize on the samples already collected for *P. ramorum* surveys and utilize new, more affordable DNA-sequencing technology for identification—given a modest additional investment of expertise, time and equipment.

Objective 3: Determine if currently used, commercially available test kits are providing consistent results.

We will compare ImmunoStrip® technology with enzyme-linked immunosorbent plate assays (ELISA) for *Phytophthora* identification. Over the years, we experienced mixed results but have not had the opportunity to run side by side comparisons that would provide definitive answers on the validity of the current testing procedure. The comparison of this project allowed us to determine the validity of the current testing procedures. The outcome of the project showed that when comparing results, 4% of the

ImmunoStrip® testing indicated a false negative result. Due to this pathogen being of regulatory concern, even a 3% difference is not acceptable.

Goals and Outcomes Achieved

The first objective addressed for this project was the serological testing and using the two test process performed to meet Objective 3 in the work plan, "Determine if currently used, commercially available test kits are providing consistent results". The two test process included testing all appropriate submissions first both with the currently accepted ELISA method and secondly with the newer, ImmunoStrip® technology. The number of samples tested with both test methods was 136 of the 150 submissions (14 samples were not tested because they were BOB samples that went straight to PCR according to the testing protocols or were not tested using ELISA/ ImmunoStrip®). The results of the ImmunoStrip® matched the result of the ELISA testing 132 times out of the 136 samples. Therefore, 4 times out of 136, the testing results did not match and the ImmunoStrip® produced negative results when the ELISA produced positive results. This is significant because although the percentage with different results was low; if, as in this case, they were regulatory significant samples, any difference may be too great because 3% of the samples would not have gone on in the testing process to determine if *P. ramorum* was present if they were only tested using ImmunoStrip®.

The samples in place were used to conduct the next objective, Objective 1: Survey for *Phytophthora kernoviae* in *P. ramorum* samples. Of the 150 samples received and processed, we determined which samples would be used in the *P. kernoviae* step of this project by determining which samples tested positive for a *Phytophthora* species using the ELISA test kits and/or which samples were submitted for *P. ramorum* testing that went straight to PCR processing (no ELISA test done). The analysis resulted in 73 samples matching our criteria. The 73 samples were processed using two molecular, polymerase chain reaction (PCR) tests; the ITS1 and ITS2 protocols for *P. kernoviae* identification. Each sample was first tested using the ITS1 protocol followed by a second test using the ITS2 protocol. All the testing worked as expected and results included good positive and negative controls. Each PCR also included an internal control. The ITS1 internal control uses the 5.8S primer and probe which identifies if plant DNA is present which indicates that the DNA extraction step worked properly. The ITS2 internal control uses the COX primer and probe, which identifies if a *Phytophthora* species is present and, of course, this should be the case for all of our samples used in this part of our testing because our criteria for selection included positive *Phytophthora* species-ELISA results. All 73 samples produced negative results in ITS1 and ITS2 for the presence of *P. kernoviae* and produced good internal controls for both rounds of testing with indications of the 5.8S-Phytophthora species presence for each samples and good COX-DNA presence for each sample, therefore no *P. kernoviae* was found.

The technician began the final objective, Objective 1, by developing the processing plans to achieve successful sequencing as outline in Objective 1. The processing began in January of 2015. The processing plan entailed a very complex process with seven steps.

The steps are provided here:

1-Nested PCR round 1

2-Nested PCR round 2

3-Cloning which includes ligation, transformation, and picking colonies

4-Conventional PCR

5-Sequencing preparation

6-Blast sequences to speciate *Phytophthora*

The process can fail at any step. The steps are needed for the following reasons: a) the nested PCR (2 runs) determines which samples will be successful in the cloning process by amplifying the targeted *Phytophthora* sequence, b) the cloning process identifies and isolates individual organisms, c) the conventional PCR step amplifies the cloned organism, d) the sequencing preparation cleaned up the DNA in order to maximize the chances of successful sequencing and e) blasting the sequences compared the DNA sequences to all those in GenBank, at the National Center for Biotechnology Information (NCBI) website, to look for similarities and possibly suggest a name. Many of the samples were pond baited leaves and samples were submitted in batches of three from each pond on a site. Because this was an elaborate process, it was decided to use one sample from each batch since they most likely contained similar organisms. Since these were all environmental samples, the chance that more than one Phytophthora species could be present in each sample was very high. So it was determined that cloning the samples would be the best method of isolating a single organism, which is needed to be successful for sequencing. The cloning process can produce numerous clones so we chose ten of the clones from each sample to sequence. Of the 150 samples, it was determined that 33 samples were the best candidates for the sequencing step. A problem with DNA fragment size caused a number of unsuccessful sequencing attempts in the beginning of the process. The method was modified and samples attained a 100% successful cloning level. Of the 33 proposed samples, 28 were successfully cloned with 205 clones generated and successfully sequenced. The following listing provides the species name and the number of times it was identified in the 205 successful sequencings: *Phytophthora borealis* (2), *P. cactorum* (14), *P. citricola* (55), *P. citrophthora* (44), *P. crytogea* (51), *P. gonapodyides* (2), *P. hibernalis* (6), *P. hydropathic* (7), *P. lacustris* (4), *P. megasperma* (1), *P. parsiana* (1), *P. pini* (5), *P. plurivora* (11), *P. riparia* (1) and *Phytopythium litorale* (1)

P. cactorum (13) causes rhododendron root rot and bleeding canker in hardwood trees, it is found internationally but mostly in temperate regions and it has a large host range (over 200 species). *P. citricola* (38) causes canker, crown rot, fruit rot, root rot and bleeding canker on several economically important plants; it is found in Europe and North America and it has a large host range. *P. citrophthora* (34) causes *Phytophthora* root rot and is most active in the cooler (winter) months, when plants are dormant; it is found internationally and it affects several host plants, most commonly citrus. *P. cryptogea* (51) can survive in irrigation water and soil without a host presence for up to 4 years; it is found internationally and it has a large host range, especially ornamentals, fruits and vegetables. *P. gonapodyides* (2) is a minor pathogen causing *Phytophthora* root rot in the US (CA), Hungary, Spain, New Zealand, and the UK and its host range is primarily a few ornamental plants. *P. hibernalis* (6) is a newly discovered plant pathogen with a DNA sequence that is very similar to *P. ramorum* & *P. lateralis (*the ITS2 region is 100% homologous to *P. ramorum),* it is *f*ound internationally but in the United States it has only been confirmed in California and Oregon and the primary hosts are believed to be citrus, rhododendron and rose. *P. hydropathica* (7) is a newly discovered plant pathogen found in irrigation water which causes leaf necrosis, shoot blight, collar rot, and wilting; some references indicate it is found in the United States only in Virginia and also in Italy; there is limited information available regarding it's host range but *Rhododendron* 'catawbiense', *Kalmia latifolia*, and *Viburnum* spp. are referenced in the literature available. *P. lacustris* (4) is found in Australia, New Zealand, Europe and the US and references indicate it has several host plants. *P. megasperma* (1) causes *Phytophthora* root rot and is found internationally in the US, Canada, Mexico, South America, Europe, India, China, Australia; it is found commonly on a variety of host plants to include agricultural crops such as asparagus, cabbage,

cauliflower, carrots, and potato, as well as hollyhock, rose and Douglas fir. *P. parsiana* (1) is a newly discovered species that is tolerant of high temperatures which is uncommon for *Phytophthora* species, it infects both high and low temperature tolerant plant species, it has been reported in the US and Iran and its host range includes pistachio, fig, and almond. *P. pini* (5) is closely related to *P. citricola* and morphologically similar to *P. pini* and *P. citricola,* it is often found in samples taken from waterways and irrigation reservoirs, it is found in the US, Canada, Europe, and Japan and it's host range includes seven genera of plants including ornamentals such as the European beech and vegetables. *P. pluivora* (1) is a very aggressive soil-borne, root rotting plant pathogen, it is unclear where it is found geographically and its host range includes Rhododendron and Pieris species.

The Technician and the Diagnostician entered information into the PDDC's database and onto a spreadsheet for coordination during this project. The Director and/or the Technician replied to clients and uploaded information to the NPDN National Repository.

In summary, we learned: 1) *Phytophthora kernoviae* was not identified in the samples collected from the nurseries surveyed in 2014; 2) the species level of *Phytophthora* was identified for 205 individual organisms using cloning and sequencing techniques, which included a total of 12 different plant pathogenic species and two non-plant pathogenic species of *Phytophthora*; and 3) the comparison of the two commercially available kits for identification of a *Phytophthora* species presence indicated that the use of the ImmunoStrip® may not be an option since 4% of the samples produced different results versus ELISA.

Beneficiaries

This project benefitted the nursery growers and other green industry members of New York State and information was provided to them directly or through interaction with the section of Plant Pathology and Plant-Microbe Biology faculty and staff, Cornell Cooperative Extension Educators, NYSDAM Inspectors and Regulators and New York State Department of Environmental Conservation (NYSDEC) personnel. Additionally, other plant disease diagnosticians benefitted by learning of the results of this project, especially for the comparison of using the ELISA versus the ImmunoStrip®.

An oral presentation about the project's results was given on November 4, 2015 at the Cornell University Agriculture & Food Systems In-Service. The presentation was given by Karen Snover-Clift. Karen for 45 minutes with 23 attendees.

Many personnel from the institutions listed above attended webinars given by Snover-Clift about the results of the project. Two webinars were given; one on September 18, 2015 which was geared more towards Extension Educators and a second on September 29, 2015 which presented the same information as the first one but included a bit more technical information since it was prepared for an audience of NYSDAM and NYSDEC staff. A link to the recording of the webinar can be found in the "Additional Information" section of this report. Also, the results will be provided to these groups by Snover-Clift and Margery Daughtrey during the upcoming winter meetings that attract landscapers, arborists, educators and nurseryman. Because there was a period of time when a technician was absent from the project and processing of samples was delayed a bit, crafting a paper has been delayed as well but Snover-Clift, Allen and Daughtrey are reviewing the results and drafting a paper to be submitted to a nursery trade journal such as *Nursery Management*.

Numerous outreach activities were performed to convey the findings of this project. Seven presentations (5 oral and 2 poster) were given to ~2037 participants. Additionally, portions of the

project were discussed during Master Gardener presentations on 5 occasions for 216 participants. Title slides and the posters are pasted at the end of this document.

The posters created for two meetings, the APS meeting in August of 2015 and the NPDN National Meeting in March of 2016 gave us the opportunity to describe the project and draft a paper that will go to a trade publication such as Nursery Management in the coming months. Although that publication has not been submitted, a number of other outreach activities were completed and continue well after the end date of the project.

The following outreach activities have been completed:

-Poster presentation, March 2016, NPDN National Meeting, Washington, DC, ~220 meeting participants (image attached at the end of this document);

-Oral presentation, "Plant Disease Diagnostic Clinic; Projects studying Sudden Oak Death and Oak Wilt" November 2015, Agriculture and Food System Inservice, Ithaca, New York, 23 meeting participants (Image attached at end of document);

-Oral webinar, "Findings on Testing Procedure for *Phytophthora* Pathogens in NYS Nurseries; What are we learning?" September 2015, Cornell University-Cooperative Extension Educators Webinar, Ithaca, New York, 12 meeting participants;

-Oral webinar, "Findings on Testing Procedure for *Phytophthora* Pathogens in NYS Nurseries; What are we learning?", September 2015, NYS Department of Agriculture and Markets and NYS Department of Environmental Conservation Webinar, Ithaca, New York, 31 meeting participants;

-Poster presentation, August 2015, American Phytopathological Society (APS) National Meeting, Pasadena, California, ~1,500 meeting participants (Image attached at end of document);

-Oral presentation, "Sudden Oak Death and *Phytophthora ramorum*: New Identification Technologies, Management Strategies and what these Mean to You", January 2015, New York State Turf and Landscape Association (NYSTLA) Professional Turf & Landscape Conference and Trade Show, Yonkers, New York, 151 meeting participants (Image attached at end of document);

-Oral presentation, "The Ecology of Regulatory Significant *Phytophthora* species in New York", September 2014, Ornamental Workshop on Diseases and Insects, Hendersonville, North Carolina, ~120 meeting participants.

-Aspects of the project were described to Master Gardeners during presentations given at Master Gardener workshops;

- Master Gardener Meeting, Cortland, NY; February 2016; 27 participants
- Master Gardener Meeting, Canandaigua, NY; September 2015; 29 participants
- Master Gardener Meeting, Syracuse, NY; April 2015; 42 participants
- Master Gardener Meeting, Ballston Spa, NY; March 2015; 76 participants
- Master Gardener Meeting, Ballston Spa, NY; March 2014; 42 participants

The impact of this project includes the following:

- Participants learned that a very harmful and economically threatening pathogen (*Phytophthora kernivae*) to New York greenhouse and nursery growers and to the environment and natural areas of New York and the east coast is currently not found in 2014 samples that display similar symptoms.
- Discussing this project has created an additional format for conveying the importance of not introducing exotic pathogens and just how harmful and damaging an exotic introduction can be by making comparisons to the more commonly known Chestnut Blight and Dutch Elm Disease. These introductions can cause immeasurable long term biodiversity and ecosystem damage that may include the loss of species which in turn can cause damage to other groups such as arthropods and herbivores. These events can cause extreme economic damage to our natural systems and loss of livelihood to forest and nursery producers when infected or suspected to be infected plants must be destroyed.
- Participants learned that a commercially available identification method for *Phytophthora* species gave us a false negative in 3% of the samples we tested. This finding clearly indicates that at this time, this method should not be used for regulatory samples because if a false negative is produced, a possible harmful pathogen could be introduced into our communities and natural areas. An introduction of a harmful pathogen can cause the loss of one or more plant species, require costly eradication efforts and possibly affect greenhouse and nursery marketing.

A significant value that came out of this project was that different species of Phytophthora could be identified using molecular and sequencing techniques developed by the Plant

Lessons Learned

A number of steps in the sample processing were modified to improve efficacy and efficiency. When first processing samples for the sequencing objective, the amount of DNA produced turned out to be too low during the PCR purification step (one of the later steps in the sequencing process). Increasing the amount of DNA was crucial to ensure successful sequencing attempts. Papers were referenced and experts consulted to determine possible modifications that could be made to the protocol that would allow for more DNA to be retained. Two changes were made that significantly increased the amount of DNA present. First, the buffer was heated prior to use and second, the incubation time was increased from one minute to five minutes. Later in the processing of samples, the level of DNA began to become an issue for a second time. This time the elution step was repeated and that modification rectified the low level of DNA issue.

One of the biggest issues that arose during this process was the issue of using environmental samples that might contain numerous species of *Phytophthora*. Only one organism can be in place during the sequencing process or it fails. The cloning was a necessary step but it was also very time consuming. A change was made to the sequencing preparation step after consulting with an expert within the PPPMB section. The sequencing facility recommends performing a calculation, which for a plate of 94 samples was very time consuming and labor intensive. Our expert suggested sending the maximum amount of DNA allowed by the facility instead of performing the calculation. The results

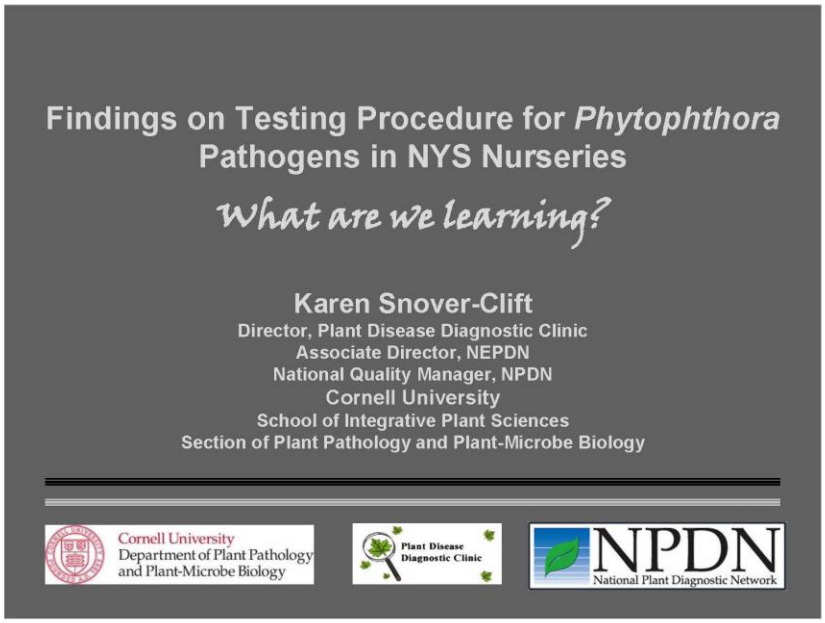
returned with successful sequences and by always sending 17ul of DNA, it was a huge labor savings that cut the time needed to prepare the samples by 70%.

Pre- and post-testing was proposed as a way of gauging what we present to a group of people, but we learned that these are not easily executed especially when given short periods of time to present information. When given 20 or 30 minutes to present such a large project, the time needed to deliver the testing, could have been used up with just the testing. Therefore, the testing was not done and the time available was just used to provide the content to the audience. This was also not feasible with the poster presentation format.

Additional Information

Agriculture and Food Systems Inservice Presentation; November 2015:

Link to webinar titled: **Findings on Testing Procedure for *Phytophthora* Pathogens in NYS Nurseries; September 2015**
https://vimeo.com/139760843



NYSTLA Presentation; January 2015:

Ornamental Workshop on Disease and Insects, September 2014:

NPDN National Meeting Poster, March 2016:

Cornell University

Beyond *Phytophthora* ramorum: Identifying other *Phytophthora* species, searching for *P. kernoviae* and evaluating species level testing methods

Authors: Karen Snover-Clift[1], Margery Daughtrey[2], Tricia Allen[1], Sandra Jensen[1]
[1]Cornell University, Section of Plant Pathology and Plant-Microbe Biology, Plant Disease Diagnostic Clinic (PDDC), Ithaca, NY
[2]Cornell University, Long Island Horticultural Research and Extension Center, Riverhead, NY[2]

Abstract: Beginning in 2004, the Cornell University's Plant Disease Diagnostic Clinic (PDDC) has provided *Phytophthora ramorum* identification testing for numerous state and national surveys, trace forward/back events and Farm Bill projects. Since 2004, 3,695 suspect *P. ramorum* samples have been processed. Working with so many samples has triggered questions in regards to the process and our findings. Currently only the ELISA procedure is accepted by regulatory agencies for preliminary testing to the *Phytophthora* genus level. However, the ImmunoStrip® is an ideal diagnostic tool for small sample sets, therefore, a comparison of results may allow this alternative procedure. Furthermore, ELISA testing indicated that many of the samples processed contained a *Phytophthora* species but no species identification testing was done due to the additional cost of labor and supplies needed. Another significantly harmful *Phytophthora* species, *P. kernoviae*, has not yet been identified in the United States: monitoring for it is not common practice. Testing plants for *P. kernoviae* is important because this pathogen is reportedly much more damaging; it was found in Europe during their *P. ramorum* surveys. A Specialty Crop Block Grant allowed us to accomplish three objectives, using our 2014 samples: 1) sequence *Phytophthora* positive samples, 2) test samples using qPCR ITS1 and ITS2 protocols for *P. kernoviae*, and 3) compare the ELISA *Phytophthora* species procedure with the ImmunoStrip® test. This project allowed us to name 14 different *Phytophthora* species detected from 205 isolates, determine no *P. kernoviae* was present in these samples and show a few differences between results of ELISA versus Immunostrip®.

METHODS – objective #1

Each sample was tested twice using the ITS1 & ITS2 protocols for *P. kernoviae* identification. The ITS1 protocol uses primers Pkern 60F and Pkern 121R, and the Pkern 84T probe. It also contains an internal control 5.8S primer and probe which indicates if a *Phytophthora* species is present. The ITS2 protocol uses primers Pkern 615F and Pkern 722R and the Pkern 606T probe. It also contains an internal control COX primer and probe which indicates if plant DNA is present and, therefore, shows whether the DNA extraction step worked properly.

Plant Disease Diagnostic Clinic

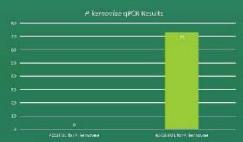
METHODS – objective #2

Because these were environmental samples, each sample was molecularly cloned in hopes of isolating different species present. The sequencing preparation steps are listed below:

- **Nested PCR (round 1):** primers: 18Ph2F, 5.8-1R
- **Nested PCR (round 2):** primers: ITS6, 5.8-1R
- **Molecular Cloning:** Promega Easy Vector II Kit
- **Conventional PCR:** universal primers: pUC/M13F, pUC/M13R
- **Quantify DNA & prep for sequencing:** prepared 2 samples per clone (forward & reserve directions)
- **Sequence:** Cornell University Genomics Core facility
- **Sequence alignment:** Geneious Software by Biomatters
- **BLAST Sequences:** NCBI database

RESULTS – objective #1

The results for all 73 samples for ITS1 & ITS2 were NEGATIVE; NO *P. kernoviae* detected.



CONCLUSION – objective #1

Although *Phytophthora kernoviae* has not been detected in the US, it has been detected in Europe and was reported to be a more damaging pathogen than *P. ramorum*. In Europe, *P. kernoviae* was first discovered accidently during *P. ramorum* testing. For that reason and because we have not searched for this pathogen in the past, we tested all of our 2014 *P. ramorum* samples using the molecular protocols validated by the USDA-APHIS-PPQ-S&T-Beltsville Laboratory facility.

Based on this survey, our findings indicated that *P. kernoviae* was not detected in sampled nurseries.

OBJECTIVE #1
Survey for *P. kernoviae*

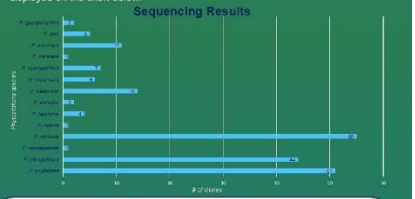
Objectives were satisfied using samples originally submitted to the Clinic for *P. ramorum* testing. These samples all tested positive for a *Phytophthora* species using the ELISA test.

OBJECTIVE #2
Sequence unknown *Phytophthora* species samples

OBJECTIVE #3
Compare test results: ELISA vs. ImmunoStrip®

RESULTS – objective #2

Approximately 7 clones were chosen from each sample. In sum, 204 clones were generated from 30 samples and sequenced. The *Phytophthora* species identified are displayed on the chart below.



CONCLUSION – objective #2

The goal of this portion of the project was to learn more about specific *Phytophthora* species present in New York State nurseries. Sequencing the *Phytophthora* species enabled us to learn which species were present in samples that tested negative for *P. ramorum*. Rather than stopping at a negative test result for *P. ramorum* with the survey samples as in the past (due to insufficient funding), this state-funded project allowed for the additional analysis of samples that contained pathogens related to *P. ramorum*. Through further analysis of nursery samples, we are beginning to increase our knowledge of the *Phytophthora* species present in New York State nurseries, which may lead to a better understanding of *Phytophthora*-related disease damage on nursery plants.

Numerous species of *Phytophthora* are being identified in the survey samples collected as part of the *P. ramorum* survey. The ability to clone and sequence the other *Phytophthora* species is providing useful information that may help us better understand *Phytophthora*-related plant damage.

METHODS – objective #3

All samples received from New York State sites for *P. ramorum* survey processing were tested following the approved protocol using Agdia's PathoScreen *Phyt* (ELISA for *Phytophthora*) kit to determine if a *Phytophthora* species was present and if additional testing was needed. The study also tested each sample with Agdia's ImmunoStrip® test strip to determine if consistent results would be found.

RESULTS – objective #3

The results of the ImmunoStrip® matched the results of the ELISA testing 132 times out of the 136 samples. Therefore there were 4 samples which produced conflicting results using these two tests.

For these 4 samples, the ELISA test produced a positive result while the ImmunoStrip® results were negative. During sequencing analysis (objective #2) of the 4 samples, 2 were sequenced. One sample was identified as *P. citrophthora* and the other was *P. citricola*.

CONCLUSION – objective #3

There are times when it is more convenient to use the ImmunoStrip® test strip rather than the ELISA. This study was important because the Cornell PDDC often receives single samples and the ImmunoStrip® is the ideal test method in this situation. The ELISA kit can be used for any number of samples, but repeated use with a low number of samples uses up the reagents quickly and the kit's testing capacity is drastically reduced. Because of this it would be ideal to use the ImmunoStrip® for single samples and the ELISA for processing larger groups of samples to minimize waste. Since there was variation between the two different test methods (ELISA vs. ImmunoStrip®), such that the ImmunoStrip® missed four samples that were positive in the ELISA testing, the risk of not finding a positive result in the *Phytophthora* screening is too high when processing regulatory samples.

One hypothesis is that the ImmunoStrip ® is less sensitive detecting specific *Phytophthora* species while the ELISA test can detect a larger range of species. To test this hypothesis we would like to research the different levels of detection each test provides. If funding is procured, we plan to use Elicitin qPCR, paired with sequencing analysis, to formulate beneficial data that could be used to better prepare for detecting *Phytophthora* species in the future and provide more insight into the validity of these tests.

Link to webinar titled: Findings on Testing Procedure for *Phytophthora* Pathogens in NYS Nurseries; https://vimeo.com/139760843

APS Poster:

Cornell University

Expanding the *Phytophthora ramorum* Sample Processing: Searching for *Phytophthora kernoviae*, Identifying *Phytophthora* species, and Evaluating a Test Method

Plant Disease Diagnostic Clinic

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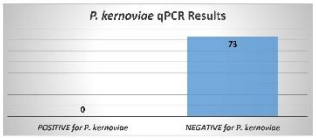
ABSTRACT
Phytophthora ramorum is an exotic pathogen that first appeared in the US as a killer of oaks and tanoaks in California in the mid-1990s. It has a wide host range that includes many trees and shrubs in eastern forests and gardens. Surveys for *P. ramorum* began in 2004 when a large nursery in California discovered the pathogen and it was realized that it might have been shipped to many states. New York places a high priority on excluding this pathogen. We have recently learned about *Phytophthora kernoviae*, a new pathogen with a wide host range that may be even more damaging, but has not yet been found in the US. This project will make further use of state *P. ramorum* survey samples by adding molecular testing for *P. kernoviae*, identifying all of the different *Phytophthora* species collected (not just the target *P. ramorum*) and evaluating the consistency of identification results with two alternative techniques. Samples collected in the 2014 survey were used in these experiments. As a result, we will obtain extensive, valuable data on the other *Phytophthora* pathogens in NY nurseries, will provide definitive answers on the validity of the current testing procedures, and may find out whether *P. kernoviae* is present in New York State.

OBJECTIVE 1:
Survey for *Phytophthora kernoviae* in *P. ramorum* samples

All samples received from New York State sites for *P. ramorum* survey processing that were ELISA positive in the screening step of the survey process were also tested for the presence of *P. kernoviae* using the ITS1 and ITS2 PCR protocols.

73 samples met the above criterion and were therefore tested for *P. kernoviae* using molecular analysis.

METHODS & RESULTS:
Each sample was tested twice using the ITS1 & ITS2 protocols for *P. kernoviae* identification. The ITS1 protocol uses primers Pkern 60F and Pkern 121R, and the Pkern 84T probe. It also contains an internal control 5.8S primer and probe which indicates if a *Phytophthora* species is present. The ITS2 protocol uses primers Pkern 615F and Pkern 722R and the Pkern 606T probe. It also contains an internal control COX primer and probe which indicates if plant DNA is present and, therefore, shows whether the DNA extraction step worked properly.



The results for all 73 samples in ITS1 & ITS2 were NEGATIVE; NO *P. kernoviae* detected

CONCLUSION:
Although *Phytophthora kernoviae* has not been detected in the US, it has been detected in Europe and was reported to be a more damaging pathogen than *P. ramorum*. In Europe, *P. kernoviae* was first discovered accidently during *P. ramorum* testing. For that reason and because we have not searched for this pathogen in the past, we tested all of our 2014 *P. ramorum* samples using the molecular protocols validated by the USDA-APHIS-PPQ-S&T-Beltsville Laboratory personnel.

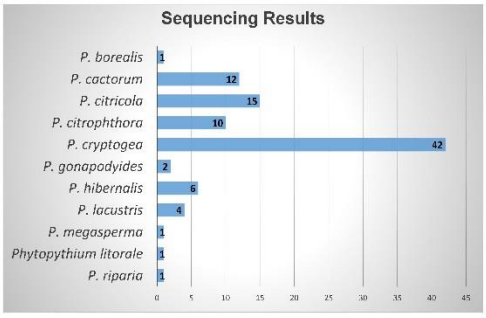
Based on this survey, our findings indicated *that P. kernoviae* was not detected in sampled nurseries.

OBJECTIVE 2:
Determine the *Phytophthora* species present in samples that contain a *Phytophthora* other than the target species, *P. ramorum*.

METHODS:
Because these were environmental samples, each sample was molecularly cloned in hopes of isolating different species present. The 7 major steps for sequencing preparation and analysis are listed below:

1-Nested PCR (Round 1): primers: 18Ph2F, 5.8-1R
2-Nested PCR (Round 2): primers: ITS6, 5.8-1R
3-Molecular Cloning: ligation, transformation, pick & grow colonies
4-Phytophthora PCR: primers: pUC/M13F, pUC/M13R
5-Sequencing prep stage: measuring PCR product concentration (NanoDrop), proper calculations.
6-Sequencing: Samples were sent to the Cornell University Genomics Core Facility for sequencing
6-Sequences assembled and identified: Geneious Software

RESULTS:
Up to 10 clones were used from each sample. To date, 95 clones, generated from 16 samples, have been prepared and sequenced. The *Phytophthora* species identified are displayed in the table below.



CONCLUSION:
The goal of this portion of the project was to learn more about specific *Phytophthora* species present in New York State nurseries. Sequencing the *Phytophthora* species enabled us to learn which species were present in samples that tested negative for *P. ramorum*. Rather than stopping at a negative test result for *P. ramorum* with the survey samples as in the past (due to insufficient funding), this state-funded project allowed for the additional analysis of samples that contained pathogens related to *P. ramorum*. Through further analysis of nursery samples, we are beginning to increase our knowledge of the *Phytophthora* species present in New York State nurseries, which may lead to a better understanding of *Phytophthora*-related disease damage on nursery plants.

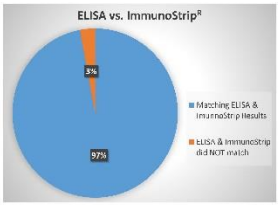
Numerous species of *Phytophthora* are being identified in the survey samples collected as part of the *P. ramorum* survey. The ability to clone and sequence the other *Phytophthora* species is providing useful information that may help us better understand *Phytophthora*-related plant damage.

OBJECTIVE 3:
Determine if currently used, commercially available test kits are providing consistent results

All samples received from New York State sites for *P. ramorum* survey processing were tested following the approved protocol using Agdia's PathoScreen *Phyt* (ELISA for *Phytophthora*) kit to determine if a *Phytophthora* species was present and if additional testing was needed. The study also tested each sample with Agdia's ImmunoStrip® test strip to determine if consistent results would be found.

The comparison of the results from using both the ELISA and the ImmunoStrip® will be used to assess consistency between the two different test methods.

RESULTS:
The results of the ImmunoStrip® matched the results of the ELISA testing 132 times out of the 136 samples.



Four times out of 136, the test results did NOT match: The ImmunoStrip® produced a negative result while the ELISA produced a positive result.

CONCLUSION:
There are times when it is more convenient to use the ImmunoStrip® test strip rather than the ELISA. This study was important because the PDDC often receives single samples and the ImmunoStrip® is the ideal test method in this situation. The ELISA kit can be used for any number of samples, but repeated use with a low number of samples uses up the reagents quickly and the kit's testing capacity is drastically reduced. Because of this it would be ideal to use the ImmunoStrip® for single samples and the ELISA for processing larger groups of samples to minimize waste. Since there was variation between the two different test methods (ELISA vs. ImmunoStrip®), such that the ImmunoStrip® missed four samples that were positive in the ELISA testing, the risk of not finding a positive result in the *Phytophthora* screening is too high when processing regulatory samples

Contact Person

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Project 7 (FINAL)

An Insect, Disease and Weed Management Program for New York Organic Apples

Project Summary

Organic apple production in the eastern U.S. is small and is mostly based on existing varieties, which are susceptible to scab, and rootstocks, which are susceptible to fire blight. As a result, this requires numerous sprays per year of various pesticides to produce acceptable fruit. The incorporation of disease-resistant varieties and rootstocks would greatly reduce the number of sprays required to produce high quality apples. To be profitable, new organic orchards should use the latest technology in high density orchards, which begin production in the second or third leaf and can achieve 50% higher yields than traditional orchards.

Our intention with this project was to use a newly planted high-density organic apple orchard of the most promising disease-resistant varieties in order to evaluate and demonstrate the most advanced and effective tactics available to the NY fruit industry. The evaluation included assessment for fruit production, organically acceptable management of arthropod and disease pests, as well as chemical and mechanical weed control measures and their effects on tree growth. Overall, we expected this project to lead to increased commercial organic apple production in New York State to meet the demand of a segment of NY consumers who want locally produced organic apples. This work should help make this economic opportunity accessible to a wider group of NY apple growers.

Project Approach

Substantial disease and arthropod problems pose barriers to the adoption of organic apple production in NY, which have discouraged commercial apple growers from accessing these potentially lucrative alternative markets, except in niche market situations such as roadside and farmers' markets. However, advanced integrated pest management and more effective biological control tactics have been used recently in the northeastern U.S., and new formulations of biopesticides, biological control agents, insect viruses, and pheromone disruption have become available, but are not well understood by most growers. Similarly, there are a number of new scab-resistant varieties that have high fruit quality but are new to NY apple growers. The incorporation of scab-resistant varieties and fire blight-resistant rootstocks would greatly reduce the number of sprays required to produce high quality organic apples. Advances have also been made in weed mulches and suppression techniques, chemical thinning strategies, and foliar nutrient formulations. The confluence of these factors could increase the potential for organic apple production in NY.

The purpose of this project was to use a newly established designated high-density organic apple orchard of the most promising disease-resistant varieties to evaluate and demonstrate the most effective and best recommended practices available to NY apple growers interested in organic production. Insect, disease and weed management programs were compared over two growing seasons in a dedicated organic apple research orchard at Cornell's Geneva Experiment Station. The orchard was planted in the spring of 2012 and consists of a 2.4-acre (2,400 trees) organic apple orchard containing replicated plots of nine disease-resistant varieties on two disease-resistant Geneva® rootstocks: Pristine, Williams Pride, NovaEasygro, Crimson Crisp, Juliet, Modi, Topaz, Goldrush, NY-13 and NY-1211; the rootstocks used are G.202 and G.935. The plot was planted in a modern high-density tall spindle orchard system at a spacing of 3' x 12', giving a planting density of 1210 trees/acre. Trees have been trained as a slender fruiting wall. The plot has 3 replications with varieties in whole rows of 62 trees of each variety in each rep.

Goals and Outcomes Achieved

Evaluation of efficacy of arthropod management tactics available for organic apple plantings - Agnello

Different arthropod management regimens compared 3 treatment levels: Advanced Organic, using the most efficacious options available (predatory mites, entomopathogenic nematodes [EPNs], neem oil, Entrust [spinosad], Surround [kaolin clay]); Minimal Organic, employing tactics that technically meet most common certification standards, but with a greater reliance on options that are more commercially available, less expensive and easier to implement (Dipel [B.t.], Pyganic [pyrethrin], Aza-Direct [azadirachtin]; and an Untreated Control. A season-long spray program was maintained, with applications starting at bloom (2014) or tight cluster (2015), and proceeding through August. Pheromone traps were deployed to track flights of the major moth pest species, and fruit and foliar samples were taken at regular timings to evaluate insect pest presence and damage in the different treatments, including overwintering and summer broods of obliquebanded leafroller (OBLR); internal feeding leps such as codling moth and lesser appleworm; green aphid and leafhopper foliar infestations; and pre-harvest fruit insect damage.

Foliar Sample Results

From the results of the in-season sampling sessions, it can be seen that in 2014, the Advanced Organic treatment was generally more effective in managing OBLR and CM populations than the Minimal Organic treatment, and that either treatment usually (although not always) maintained these populations at lower levels than were seen in the Untreated Control (Table 1). Conversely, the advanced treatment performed no better than the Minimal treatment in preventing terminal infestations of green aphids (Table 2). In 2015, both organic regimens provided fairly good control of leaf-feeding insects (Table 3), as there were no real differences between the Advanced and the Minimal treatments. Possibly, earlier initiation of treatments could have improved overall management (before natural later season population decline). The foliar mite sample on 11 Aug 2015 (Table 4) showed that both treatment regimens had below-threshold European red mite populations by the end of the season, but the numbers in the Advanced plots (as well as the Untreated check) were lower. Predator mite levels were optimal and comparable in both treatments, although marginally higher in the untreated check.

In terms of overall fruit insect damage present at harvest, the mean damage ratings were somewhat variable according to variety, but the greatest damage was seen in the categories of plum curculio oviposition and feeding, and internal Lepidoptera (mainly codling moth) infestation and obliquebanded leafroller feeding (Table 3). The Advanced Organic treatment resulted in higher overall levels of clean fruit in the varieties Crimson Crisp, Modi, Topaz, and Goldrush; however, the Minimal Organic clean fruit levels were higher in Pristine, Nova Easygro and Juliet. The Advanced program was generally more effective than the Minimal program in the category of internal Lep/OBLR damage, and less effective than the Minimal program against plum curculio oviposition.

Table 1. Oblique banded leafroller (OBLR) and Codling moth (CM) infestation and damage samples, 2014

Treatment	Obliquebanded Leafroller				OBLR & CM
	% trees w/ larvae present		% terminal damage	% terminal infestation	% fruit damage
	5/22	6/4	7/9	7/16	7/23
Advanced Organic	40.0	6.7	10.6	0.2	1.2
Minimal Organic	35.6	12.2	12.6	0.4	2.8
Untreated	46.7	12.2	15.2	0.4	4.4

Table 2. Green aphid terminal infestation samples, 2014

Treatment	% terminal infestations			
	6/24	7/2	7/16	7/23
Advanced Organic	6.7	9.3	2.6	5.9
Minimal Organic	3.3	8.5	2.6	3.3
Untreated	7.4	5.6	7.8	6.3

Table 3. Green aphid and potato leafhopper terminal infestation samples, 2015

Treatment	% PLH infestations	% aphid infestations		
	6/30	6/30	7/16	7/22
Advanced Organic	25.6	0.7	1.9	2.6
Minimal Organic	21.1	1.1	4.8	3.7
Untreated	22.6	1.1	2.4	1.8

Table 4. Foliar mite numbers per leaf, 11 Aug 2015

Treatment	ERM motiles		ERM eggs	Predator mites
Advanced Org	2.5	2.0	0.2	
Minimal Org	7.4	7.0	0.1	
Untreated Check		0.7	0.6	0.4

ERM, European red mite

Table 5. Percent fruit insect damage at harvest, 2014-2015.

Year / Treatment	PC Ovip	PC Feeding	Internal Leps	TPB	RAA	Early OBLR	Late OBLR	SJS	Clean Fruit
2014									
Advanced	13.8a	10.0a	0.8a	3.2a	1.7a		9.2a		62.6a
Minimal	12.5a	8.0a	0.9a	3.1a	1.3a		16.1ab		59.7a
Check	13.6a	7.6a	4.0a	2.5a	1.7a		22.8b		51.5a
2015									
Advanced	8.4a	3.9a	8.4a	9.6a	4.2a	0.4a	4.8a	2.6a	60.8a
Minimal	20.8ab	3.7a	19.8b	9.0a	0.7b	0.6a	6.6a	0.6a	44.3b
Check	26.9b	2.8a	13.9ab	9.3a	2.4ab	2.8b	8.1a	2.3a	42.4b

PC, plum curculio; Ovip, oviposition; Leps, Lepidoptera; TPB, tarnished plant bug; RAA, rosy apple aphid; OBLR, obliquebanded leafroller; SJS, San Jose scale

Within a year, percent fruit levels within a pest category followed by the same letter not significantly different, $P < 0.05$, Student's t-test.

Evaluation of efficacy of organic management tactics for fire blight & summer diseases - Cox

Trials were conducted to evaluate the effectiveness of organic fungicides and bactericides for flyspeck & sooty blotch (2014 and 2015), cedar apple rust (2015) and fire blight (2015) management. Fungicide treatments were applied using an airblast sprayer at typical cover spray timings of 14 to 21-day intervals during the timings for late season diseases (mid-July to mid-September). The management program for early season diseases (2nd cover and prior) consisted of applications of micronized wettable sulfur at 21-day intervals from green tip to 2nd cover. Fire blight treatments were applied dilute to runoff using a gas powered backpack sprayer at 80% bloom in the Topaz blocks. Topaz was chosen for its susceptibility to fire blight. Trees were inoculated at full bloom with *Erwinia amylovora* strain Ea 273 at $1x10^4$ $CFUml^{-1}$ using a backpack sprayer. The incidence of flyspeck and sooty blotch symptoms was assessed for mature fruit at harvest. Blossom blight and shoot blight symptoms were assessed on blossom clusters and terminal shoots in June. The incidence of cedar apple rust symptoms on terminal leaves was calculated from the number of terminal leaves with cedar apple rust lesions with pycnidia out of eight fully expanded leaves from the distal end of the shoot.

In 2014, across all cultivars, the incidence of sooty blotch and flyspeck ranged from 2-81% and 0-40%, respectively (Table 6). With the exception of both programs on the cultivar CC1009 and Microthiol Disperss on Goldrush, both organic programs had considerably lower incidences of sooty blotch compared with the untreated check. The two organic programs usually provided a statistically equivalent level of sooty blotch control except on Goldrush, where the Cueva/Double Nickel LC program had a considerably lower incidence. Against flyspeck, both organic programs provided a statistically equivalent level of control. In many instances, the Cueva/Double Nickel LC program provided complete control of symptoms.

Table 6. Sooty blotch and flyspeck levels in selected cultivars under Advanced (ADV) or Minimal (MIN) organic management programs, 2014.

Trt	Summer treatment programs (amt./A)[y]	Timing [*]	CC1009 Sooty blotch (%) [**]	CC1009 Flyspeck (%) [**]
CHK	Untreated	1-4	64.0 ± 9.2 a	33.6 ± 8.6 a
MIN	Microthiol Disperss 15 lbs.	1-4	58.7 ± 7.5 ab	1.3 ± 0.7 b
ADV	Cueva 2 qts + Double Nickel LC 1 qt	1-4	42.7 ± 4.7 b	0.0 ± 0.0 b

Trt	Summer treatment programs (amt./A)[y]	Timing [*]	Crimson Crisp Sooty blotch (%) [**]	Crimson Crisp Flyspeck (%) [**]
CHK	Untreated	1-4	44.0 ± 4.2 a	11.3 ± 2.7 a
MIN	Microthiol Disperss 15 lbs.	1-4	11.3 ± 2.4 b	0.0 ± 0.0 b
ADV	Cueva 2 qts + Double Nickel LC 1 qt	1-4	19.7 ± 2.7 b	0.0 ± 0.0 b

Trt	Summer treatment programs (amt./A)[y]	Timing [*]	Goldrush Sooty blotch (%) [**]	Goldrush Flyspeck (%) [**]
CHK	Untreated	1-4	76.7 ± 7.7 a	13.3 ± 2.4 a
MIN	Microthiol Disperss 15 lbs.	1-4	27.6 ± 4.6 b	1.3 ± 0.7 b
ADV	Cueva 2 qts + Double Nickel LC 1 qt	1-4	2.0 ± 1.2 c	0.0 ± 0.0 b

Trt	Summer treatment programs (amt./A)[y]	Timing [*]	Juliet Sooty blotch (%) [**]	Juliet Flyspeck (%) [**]
CHK	Untreated	1-4	59.3 ± 0.0 a	40.0 ± 5.0 a
MIN	Microthiol Disperss 15 lbs.	1-4	7.3 ± 0.0 b	0.7 ± 0.7 b
ADV	Cueva 2 qts + Double Nickel LC 1 qt	1-4	8.0 ± 0.0 b	0.0 ± 0.0 b

Trt	Summer treatment programs (amt./A)[y]	Timing [*]	Modi Sooty blotch (%) [**]	Modi Flyspeck (%) [**]
CHK	Untreated	1-4	46.7 ± 5.5 a	8.7 ± 1.8 a

MIN	Microthiol Disperss 15 lbs.	1-4	8.8 ± 1.9 b	0.7 ± 0.7 b
ADV	Cueva 2 qts + Double Nickel LC 1 qt	1-4	7.5 ± 2.6 b	0.0 ± 0.0 b

Trt	Summer treatment programs (amt./A)[y]	Timing [*]	Topaz Sooty blotch (%) [**]	Topaz Flyspeck (%) [**]
CHK	Untreated	1-4	81.3 ± 6.6 a	7.3 ± 1.7 a
MIN	Microthiol Disperss 15 lbs.	1-4	6.7 ± 4.1 b	0.0 ± 0.0 b
ADV	Cueva 2 qts + Double Nickel LC 1 qt	1-4	8.7 ± 4.7 b	0.0 ± 0.0 b

[*]Treatments timings were: 1, 17 Jul–3rd cover; 2, 6 Aug–4th cover; 3, 22 Aug-5th cover; 4, 15 Sep–6th cover.

[**]All values represent the means and standard errors of five fruit from at least 10 fruit collections across 4-8 replicate trees. Values within columns followed by the same letter are not significantly different ($P < 0.05$) according to the LSMEANS procedure in SAS 9.4 with an adjustment for Tukey's HSD to control for family-wise error.

In 2015, across all cultivars, the incidence of sooty blotch on mature fruit ranged from 0-100% (Table 7). With the exception of the Cueva program (MIN) on Pristine, both organic programs had considerably lower incidences of sooty blotch compared with the untreated check. The two organic programs usually provided a statistically equivalent level of sooty blotch control except on 3 cultivars: Goldrush, Nova Easy Gro, and Topaz, where the Microthiol summer program (ADV) had a significantly lower incidence. The incidence of cedar apple rust ranged from 0.0-77% across all cultivars and treatments. Cultivars CC1009, Modi, Nova Easy Gro, and William's Pride appeared to have a high level of resistance to cedar apple rust, as observed by 0-0.7% incidence of cedar apple rust on terminal leaves for the untreated program. The two organic programs provided statistically equivalent levels of control against cedar apple rust across all cultivars. While the incidence of blossom blight was generally low in the untreated program, both the Cueva + Double Nickel LC program and the Badge X2 program provided statistically equivalent levels of control, and blossom blight incidence was lower in in both programs compared to the untreated (CHK) program.

Table 7. Sooty blotch, cedar apple rust, and fire blight levels in selected cultivars under Advanced (ADV) or Minimal (MIN) organic management programs, 2015.

Trt	Treatment programs (amt./A)	Timing [*]	CC1009-13 Sooty blotch (%) [**]	CC1009-13 Cedar apple rust (%) [**]	CC1009-13 Fire blight (%) [**]
CHK	Untreated	1-4	84.7 ± 8.4 a	0.0 ± 0.0	-
MIN	Cueva 3 qts Cueva 2 qts + Double Nickel LC 1 qt	1,2 3-9	32.0 ± 5.8 b	0.0 ± 0.0	-

	Badge X2 5 lbs.	1			
	Badge X2 1.25 lbs.	2-4			
ADV	Microthiol Disperss 15 lbs.	5-9	32.0 ± 7.2 b	0.0 ± 0.0	-
			Crimson Crisp	Crimson Crisp	Crimson Crisp
Trt	Treatment programs (amt./A)	Timing *	Sooty blotch (%) **	Cedar apple rust (%) **	Fire blight (%) **
CHK	Untreated	1-4	62.7 ± 9.7 a	77.3 ± 3.3 a	-
	Cueva 3 qts				
	Cueva 2 qts + Double Nickel LC	1,2			
MIN	1 qt	3-9	4.0 ± 2.3 b	19.3 ± 0.7 b	-
	Badge X2 5 lbs.	1			
	Badge X2 1.25 lbs.	2-4			
ADV	Microthiol Disperss 15 lbs.	5-9	9.3 ± 2.7 b	17.3 ± 11.6 b	-
			Goldrush	Goldrush	Goldrush
Trt	Treatment programs (amt./A)	Timing *	Sooty blotch (%) **	Cedar apple rust (%) **	Fire blight (%) **
CHK	Untreated	1-4	100.0 ± 0.0 a	72.7 ± 3.3 a	7.3 ± 0.5 a
	Cueva 3 qts				
	Cueva 2 qts + Double Nickel LC	1,2			
MIN	1 qt	3-9	47.3 ± 3.5 b	20.7 ± 3.7 b	0.0 ± 0.0 b
	Badge X2 5 lbs.	1			
	Badge X2 1.25 lbs.	2-4			
ADV	Microthiol Disperss 15 lbs.	5-9	6.7 ± 1.8 c	22.7 ± 4.8 b	1.0 ± 0.4 b
			Juliet	Juliet	Juliet
Trt	Treatment programs (amt./A)	Timing *	Sooty blotch (%) **	Cedar apple rust (%) **	Fire blight (%) **
CHK	Untreated	1-4	80.0 ± 4.6 a	38.0 ± 3.1 a	-
	Cueva 3 qts				
	Cueva 2 qts + Double Nickel LC	1,2			
MIN	1 qt	3-9	15.3 ± 2.9 b	13.3 ± 5.3 b	-
	Badge X2 5 lbs.	1			
	Badge X2 1.25 lbs.	2-4			
ADV	Microthiol Disperss 15 lbs.	5-9	8.7 ± 2.9 b	8.7 ± 2.7 b	-

Trt	Treatment programs (amt./A)	Timing *	Modi Sooty blotch (%) **	Modi Cedar apple rust (%) **	Modi Fire blight (%) **
CHK	Untreated	1-4	83.3 ± 1.8 a	0.0 ± 0.0 a	3.4 ± 0.5 a
MIN	Cueva 3 qts Cueva 2 qts + Double Nickel LC 1 qt	1,2 3-9	14.0 ± 3.1 b	0.0 ± 0.0 a	1.0 ± 0.7 b
ADV	Badge X2 5 lbs. Badge X2 1.25 lbs. Microthiol Disperss 15 lbs.	1 2-4 5-9	8.7 ± 5.9 b	0.0 ± 0.0 a	0.0 ± 0.0 b

Trt	Treatment programs (amt./A)	Timing *	Nova Easy Gro Sooty blotch (%) **	Nova Easy Gro Cedar apple rust (%) **	Nova Easy Gro Fire blight (%) **
CHK	Untreated	1-4	52.0 ± 5.8 a	0.0 ± 0.0 a	-
MIN	Cueva 3 qts Cueva 2 qts + Double Nickel LC 1 qt	1,2 3-9	11.3 ± 4.4 b	1.3 ± 1.3 a	-
ADV	Badge X2 5 lbs. Badge X2 1.25 lbs. Microthiol Disperss 15 lbs.	1 2-4 5-9	2.0 ± 1.2 c	0.0 ± 0.0 a	-

Trt	Treatment programs (amt./A)	Timing *	Pristine Sooty blotch (%) **	Pristine Cedar apple rust (%) **	Pristine Fire blight (%) **
CHK	Untreated	1-4	0.0 ± 0.0 b	26.7 ± 4.8 a	-
MIN	Cueva 3 qts Cueva 2 qts + Double Nickel LC 1 qt	1,2 3-9	2.7 ± 1.3 a	6.7 ± 2.9 b	-
ADV	Badge X2 5 lbs. Badge X2 1.25 lbs. Microthiol Disperss 15 lbs.	1 2-4 5-9	0.0 ± 0.0 b	0.7 ± 0.7 b	-

Trt	Treatment programs (amt./A)	Timing *	Topaz Sooty blotch (%) **	Topaz Cedar apple rust (%) **	Topaz Fire blight (%) **
CHK	Untreated	1-4	100.0 ± 0.0 a	64.0 ± 1.2 a	5.6 ± 1.0 a

MIN	Cueva 3 qts Cueva 2 qts + Double Nickel LC 1 qt	1,2 3-9	44.0 ± 4.0 b	18.0 ± 2.0 b	1.8 ± 0.5 b
ADV	Badge X2 5 lbs. Badge X2 1.25 lbs. Microthiol Disperss 15 lbs.	1 2-4 5-9	14.7 ± 1.8 c	15.3 ± 5.5 b	0.5 ± 0.5 b
Trt	Treatment programs (amt./A)	Timing *	William's Pride Sooty blotch (%) **	William's Pride Cedar apple rust (%) **	William's Pride Fire blight (%) **
CHK	Untreated	1-4	68.7 ± 6.8 a	0.7 ± 0.7 a	-
MIN	Cueva 3 qts Cueva 2 qts + Double Nickel LC 1 qt	1,2 3-9	0.0 ± 0.0 b	0.0 ± 0.0 a	-
ADV	Badge X2 5 lbs. Badge X2 1.25 lbs. Microthiol Disperss 15 lbs.	1 2-4 5-9	0.0 ± 0.0 b	0.0 ± 0.0 a	-

*Treatments timings were: 1, 22 Apr-quarter inch green; 2, 8 May-pink; 3, 12 May-80% bloom; 4, 15 May-late bloom; 5, 28 May-1st cover; 6, 6 Jun-2nd cover; 7, 25 Jun-3rd cover; 8, 17 Jul-4th cover; and 9, 5 Aug-5th cover.

**All values represent the means and standard errors of 10 leaf or fruit collections, or 20 blossom cluster collections across 3 replicates of 15 trees per treatment. Values within columns followed by the same letter are not significantly different ($P < 0.05$) according to the LSMEANS procedure in SAS 9.4.

Comparison of effect of different organic weed control measures on tree growth in a newly planted high-density, tall spindle orchard using disease resistant varieties and rootstocks – Robinson, Loran (Post-Doctoral Associate)

We conducted a season long weed control experiment with 5 treatments applied to 9 scab-resistant varieties with 3 replications. The weed control treatments were: 1) Mechanical cultivation on each side of the tree with a "wonder weeder" machine; 2) Flame weeding along each side of the tree using a propane flame machine; 3) Bark chip mulch 20 cm deep along the tree row; 4) Organic acetic acid spray; 5) Organic soap spray; 6) Organic limonene spray. Each of the treatments was applied every 3 weeks during the season starting in late May (a total of 5 applications). Weed control was assessed at 2 times during the season (August 11 and Oct. 1). After the first weed control assessment in August, all the plots were hand weeded and a second round of treatments was applied in August and September and re-assessed on Oct. 1. In October, tree growth was measured and fruit yield was recorded.

In 2014, among the weed control treatments we evaluated, the wood chips, the soap spray and the limonene spray gave the best early season weed control (Fig. 1). However, in the part of the field where Canadian thistle was a problem, even the wood chip mulch was not enough to prevent growth of

this weed. The monthly sprays of an organic soap and the organic limonene product gave excellent weed control. Monthly mechanical tillage or monthly flaming provided good weed control, but left a 10”-wide strip along the row, which caused significantly poorer tree growth. Monthly sprays of an organic vinegar product gave poor weed control efficacy in the early season but better weed control in the late season.

Tree growth was best with the wood chips, the soap spray and the limonene spray treatments (Fig. 2). The flame weeding, the mechanical weed control and the vinegar sprays resulted in significantly poorer tree growth. Yields varied among cultivars with the numbered selection from Geneva (CC1009) having the highest yield, followed by Goldrush, Williams Pride, Juliet, Topaz, Modi, Pristine, Crimson Crisp and Nova EasyGro, respectively. The trees treated with the limonene sprays and the soap sprays had the highest yields, followed by the vinegar and the wood chips treatments (Fig. 3). The mechanical and flame weed control treatments had significantly lower yields.

Fig. 1

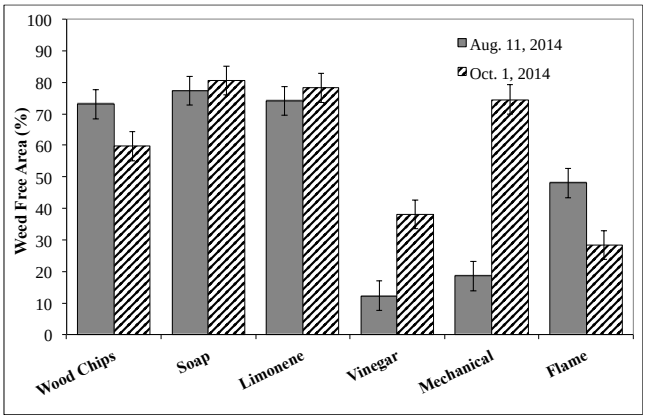

Fig. 2

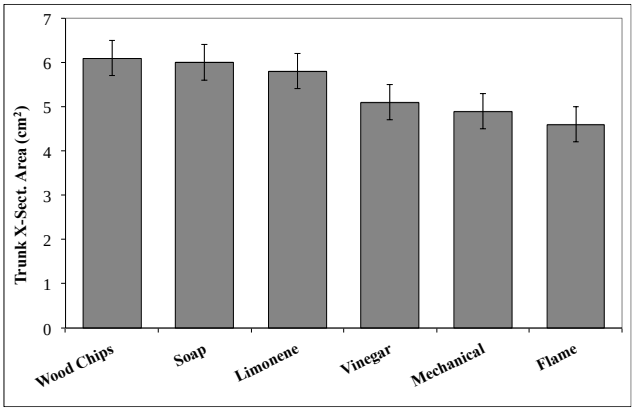

Fig. 3

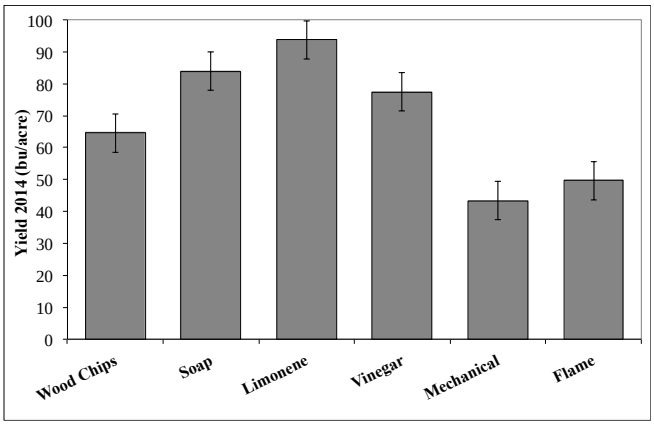

Fig. 1. Effect of various organic weed control methods on the proportion of weed free area along the tree row in 2014 at Geneva, NY.

Fig. 2. Effect of various organic weed control methods on tree growth of 9 scab resistant apple varieties on G.935 disease resistant rootstock in 2014 at Geneva, NY.

Fig. 3. Effect of various organic weed control methods on yield of 9 scab resistant apple varieties on G.935 disease resistant rootstock in 2014 at Geneva, NY.

In 2015, higher yields were observed for CC1009-13 and Modi, followed by Goldrush, Juliet, Pristine and Williams Pride (Fig. 4). Crimson Crisp and Topaz had the lowest yields.

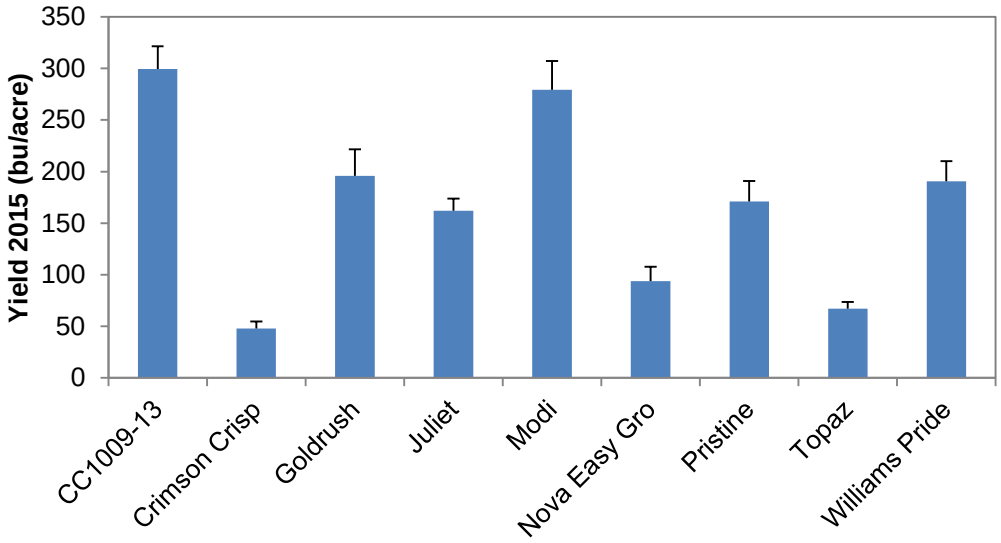

Figure 4. Yield of 9 scab resistant apple varieties on G.935 disease resistant rootstock in 2015 at Geneva, NY.

The trees treated with limonene sprays and the soap had the highest yields, followed by the caprylic acic and woodchips treatments (Fig. 5). The mechanical and flame weed control treatments had significantly lower yields.

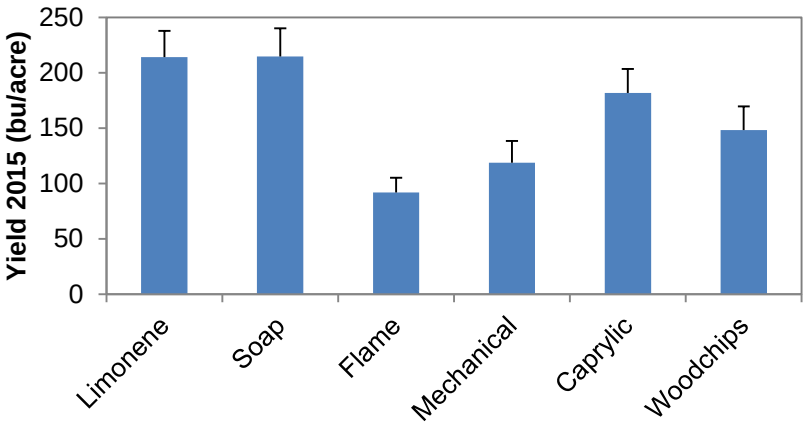

Figure 5. Effect of various weed control methods on yield of 9 scab resistant apple varieties on G.935 disease resistant rootstock in 2015 at Geneva, NY.

From the weed control trials in 2015 we have learned that the mechanical and flame weed control strategies do not control weeds along the tree row which grow to 3 ft. tall by mid-July and cause serious competition for the trees (Fig. 6). We also learned that the woodchips treatment gave good weed control but maintained an excessively high level of soil moisture, which hampered tree yield (Fig. 6). We also learned that the limonene and caprylic acid resulted in more than half of the area free of weeds, while the soap was around 50%. Spraying it more often might increase the effectiveness of the limonene, caprylic acid and soap. Overall, the best weed control resulted in the best tree yield in the fourth year. No significant differences were observed regarding fruit quality and the weed control method used (Fig. 7).

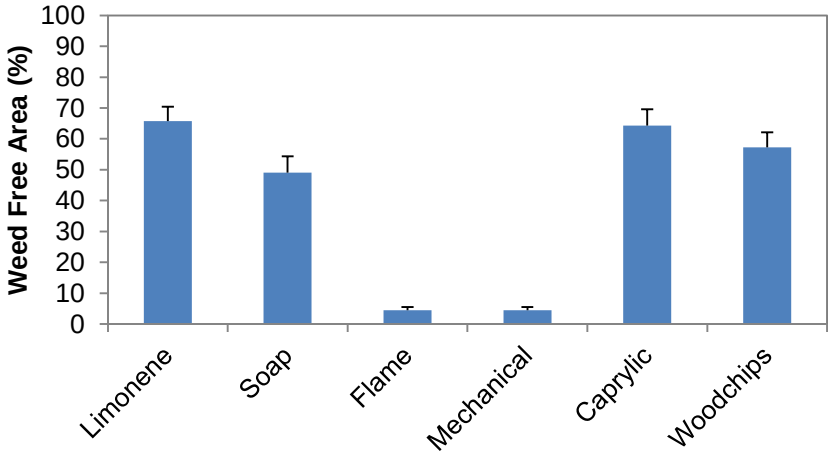

Figure 6. Effect of various organic weed control methods on the production of weed free area along the tree row in 2015 at Geneva, NY.

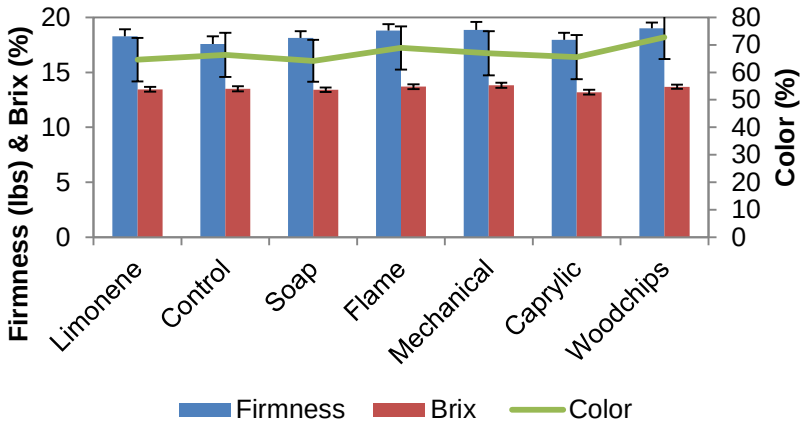

Figure 7. Effect of various organic weed control methods on fruit quality (firmness, brix and color) in 2015 at Geneva, NY.

Additionally, on 10 June 2015, an Organic Apple Field Day Workshop was held at the research site: "Organic Apple Production - Managing Productivity, Insects, Disease and Weeds" this event, which was organized and co-sponsored by NOFA-NY, comprised a 3-hour overview of the objectives, procedures and progress report of the horticultural, entomological, and plant pathological aspects of the trial being evaluated in the orchard. Presentations were given by T. Robinson, S. Brown, K. Cox, A. Agnello, and E. Shields. It was attended by 100 people, comprising growers, hobbyists, consultants and extension personnel.

Delivery of Outcomes

Project-derived insect pest management information was included in the following extension presentations:

- "Research update for woolly apple aphid and scale control", Lake Ontario Winter Fruit Schools, Lockport (Feb. 1, 2015; audience, 83) and Newark (Feb. 2, 2015; audience, 149)
- "Update on woolly apple aphid biology and control" Agr.Assistance Winter Fruit grower Meeting, Walworth (Mar. 18, 2015; audience, 200).
- "Update on San Jose scale biology and control", Upper Hudson/Champlain Tree Fruit School, Lake George (Feb. 9, 2015; audience, 65)
- "San Jose scale – An old nemesis returns", Hudson Valley Commercial Fruit Growers School, Kingston (Feb. 10, 2015; audience, 200)

In addition, a survey was administered at the Lockport, Newark, Lake George and Kingston meetings, in which growers ranked the importance of topics including organic apple production in their list of Research and Extension Priorities; the summarized information has been made available at http://www.northeastipm.org/neipm/assets/File/Priorities/Priorities-TreeFruitIPMWG-Summary-NY-Growers-2015.pdf

Also, the presentation "Advanced vs. Minimal Insect Management Programs for Organic Apple Production in NY" was given at the following regional meetings of fruit researchers, extension specialists, and private consultants:

- New England, New York, and Canadian Fruit Pest Management Workshop (October 20, 2015; Burlington, VT; audience, 30)
- 2015 Great Lakes Fruit Workers Conference, Geneva (Nov. 9, 2015; audience, 50).

Additionally, on 10 June 2015, an Organic Apple Field Day Workshop was held at the research site: "Organic Apple Production - Managing Productivity, Insects, Disease and Weeds" this event, which was organized and co-sponsored by NOFA-NY, comprised a 3-hour overview of the objectives, procedures and progress report of the horticultural, entomological, and plant pathological aspects of the trial being evaluated in the orchard. Presentations were given by T. Robinson, S. Brown, K. Cox, A. Agnello, and E. Shields. It was attended by 100 people, comprising growers, hobbyists, consultants and extension personnel.

Finally, organically approved management options for insect and disease pests of apples and other tree fruits have been incorporated (and designated as organically acceptable), along with efficacy ratings, in the 2016 Cornell Pest Management Guidelines for Commercial Tree Fruit Production), available at: https://demo.cuguidelines.net/Guidelines/TreeFruit.

Program Costs

Records were kept of the per-acre costs associated with each of the spray materials applied each year. In 2014, the cost of the Advanced Organic insect management program ($472/acre) was only 7.7% higher than that of the Minimal Organic program ($438/acre). The Advanced Organic disease management program ($226/acre) was nearly 49% more expensive than the Minimal Organic program ($152/acre). The overall cost of these combined advanced programs ($698/acre) was 18% higher than the combined cost of the Minimal programs ($590/ acre).

In 2015, the cost of the Advanced Organic insect management program ($544/acre) was 14% higher than that of the Minimal Organic program ($476/acre). The Advanced Organic disease management program ($418/acre) was twice as expensive as the Minimal Organic program ($208/acre).

The overall cost of these combined advanced programs ($961/acre) was 29% higher than the combined cost of the Minimal programs ($683/acre). These costs are actually fairly comparable to those incurred in orchards under conventional production; a 2014 Cornell Farm Business Survey gives the average pesticide cost (including insecticides, fungicides, PGRs, foliar nutrients and adjuvants) as $793/acre (range, $534-$1279/acre). However, depending on the intended market for the fruit, there was likely still more than an acceptable level of fruit damage in most of the varieties, especially in consideration of the associated control costs and increased labor.

Beneficiaries

The results of this project will primarily benefit organic apple growers in New York and the eastern U.S., but some findings will also benefit conventional farmers. It will also help ensure the production of local organic apples for consumers in the Eastern US.

There are currently an estimated 77 farm operations growing organic apples in NYS, comprising a total of 644 acres. This compares with nearly 700 farms growing conventional apples on approximately 40,000 acres. However, many of the approaches and techniques evaluated in the course of this research could be of added value to this latter group of conventional growers, as they represent some of the more innovative and cutting-edge practices being investigated for tree and pest management.

Lessons Learned

Because this orchard has been under organic management practices for only a few years, it is certain that we have not yet encountered all of the possible challenges inherent in organic apple production. For instance, we have observed good weed control from the wood chips treatment and the other soap sprays. One concern is how long wood chips will keep this high pressure area weed free, and if repetitive sprays could cause some resistance or weed selection over the years. Insect populations can be expected to continue to develop and new species and infestation patterns will likely necessitate additional measures, such as pheromone mating disruption or insect virus for internal fruit-feeding worms, and specialized trunk treatments for apple boring beetles. Fungal disease pressure at moderate levels is manageable, but copper is needed. However, it possible to use safer lower MCE copper formulations that are more environmentally more responsible. In this capacity, recommendations for organic disease management will focus on precision copper use in combination with biologicals.

From the research conducted in this project and our collective experience with organic systems over the past several decade, we intend to assemble a complete production system for organic apples in NY that combines sound horticultural practices (use of modern high-density orchards with disease-resistant rootstocks to obtain high yields and profitability), promising new disease-resistant apple cultivars that have excellent market potential, advanced insect and disease management tactics, and sustainable weed and nutrient management strategies. Within the overall system we expect to develop specific rootstock recommendations, specific cultivar recommendations, specific planting and management recommendations for the first five years of the new organic apple orchard, specific insect management tactics, specific disease management tactics and specific nutrient management protocols for sustainable production.

The expected outcome is that growers will understand how the transition to organic apple production in the northeast may impact farm profitability. This should result in increased production of organic apples in New York State and other eastern U.S. production regions. Our goal is to ultimately increase the number of commercial producers from the 9 that are primarily organic orchard operations, up to possibly as many as 100 producers of organic apples in NY. This will result in more sustainable apple production and safe and healthy food for consumers at a reasonable cost. Our project will also help ensure the production of local organic apples for consumers in the eastern U.S. This project will benefit the rural economy of apple producing counties in the eastern U.S., and will provide significant social benefits by promoting profitable agricultural enterprises in rural counties.

Photos of Organic Apple Orchard, Loomis Farm, NYSAES, Geneva, NY

Photo: Terence Robinson addresses attendees at the Organic Apple Field Day Workshop in Geneva, June 10, 2015.

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Project 8 (FINAL)
Implementation of an Area-Wide Insect Mating Disruption Participatory Program in Long Island Tree Fruit Orchards

Project Summary

Pest management is a vital part in tree fruit (apples, peaches, pears) production. Pesticide has been used in Long Island orchards for the control of various pests including oriental fruit moth (OFM), Grapholita molesta; codling moth (CM), Cydia pomonella; and lesser peachtree borers (LPTB), Synanthedon pictipes. Analysis of the pre-project years' (2012 – 2013) pesticide application records in tree fruit orchards shows most insecticide applications are driven by these three insects. Improperly used pesticides are of great concern for the Long Island's sole source underground aquifer (over 3 million people depend on it), the L.I. Sound and the Peconic Estuary. According to the 2013 NY State Department of Environmental Conservation's Long Island Pesticide Pollution Prevention Strategy (http://www.dec.ny.gov/chemical/87125.html) Draft Report: "Water quality monitoring by Suffolk County and other entities shows that pesticides are among a number of contaminants detected in Long Island groundwater as a result of a wide range of human activities". According to a 2011 NYDEC study shows that shallow private wells in agricultural areas are found to be most vulnerable to pesticide contamination, with more than 50% of the samples taken from these wells containing detectable pesticide residues. Therefore, there is a need for insecticide alternative control techniques in the Long Island fruit orchards.

Beside the long-term pesticide contamination issues, L.I. fruit growers are also facing issues quite unique from other fruit growing areas of the State. Majority of the LI's tree fruit productions are marketed as U-pick (pick-your-own) or local direct marketing (sell from fruit stand) for fresh consumption. U-pick or local direct marketing is an important part of agro-tourism for eastern L.I. attracting thousands of tourists from the New York City area as well as local residents. Timing of pesticide applications, re-entry and pre-harvest intervals are often jeopardizing harvesting and marketing of the fruits on a timely manner. Codling moth and oriental fruit moth can develop (though not documented on Long Island) resistance to many older and commonly used insecticides such as organophosphates, carbamates and pyrethroids. With increasing restrictions on insecticide use on Long Island there is interest in alternative management methods. One method, which is quickly becoming more popular, is the use of insect mating disruption (MD) using synthetically produced sex pheromones. The 'cloud' of pheromone that slowly releases from the dispensers makes it harder for males to orient to a particular female. Unmated females fail to reproduce; over time the pest population and crop damage decrease, often to a negligible level.

Project Approach

This project has engaged Long Island tree-fruit growers in adopting non-insecticidal Area-Wide Insect Mating Disruption (AWMD) program for three major tree fruit pest control in the orchards by providing 40% cost of mating disruption dispenser purchase to offset the average cost difference

between conventional insecticide and environmental friendly mating disruption techniques. The main objective of this project was to encourage growers in adopting MD technologies for a long-term basis through a program of education and outreach. The following is the list of activities and task performed in the grant period:

(1) The project investigators meet with the 11 participating tree fruit growers to discuss the establishments of the insect mating disruption (MD) program in their orchards. The investigators also evaluated the feasibility and technical aspects such placement, durability, availability, cost of the program for each block of the orchards.

(2) An insect mating disruption handout was written and published in Suffolk County Agricultural News magazine that is distributed to over 300 subscribers including fruit growers.

(3) A workshop on insect mating disruption was organized by the project investigators to educate and train growers and workers about using MD products in orchards.

(4) During the project period, each year in early spring the investigators have assessed the quantity of MD product needed for individual orchard and have growers purchased MD products and helped them placing MD ties on fruit trees at appropriate time and rate.

(5) Each year during mid-May to mid-June the CCE-SC Entomologist and Agricultural Stewardship program technicians made frequent visits to the participating orchards to ensure appropriate application of the MD dispensers.

(6) In each season during early June – mid-September, codling moth, insect monitoring traps (approx. 76 traps per/season) were set in each of the project participating orchards and traps were checked weekly. Weekly monitoring data were provided to the growers. These data helped growers understanding insect population status in orchards as well as helped researcher and extension educator's making sure the insect mating disruption technique is properly working.

(7) During the entire growing season, the project investigators made frequent visits to the participating orchards to ensure the effectiveness of MD control and performance check by random fruit scouting. Growers were also provided necessary recommendations such as information on other insects (not controlled by MD), reduced-risk insecticide option, and periodical scouting data. As for season-long performance check, prior to fruit harvest an average 18,500 apples and 4,500 peaches per year were inspected for insect related fruit damage (250 fruits/sample checked from 10 interior and 10 border trees). Codling moth, plum curculio, tarnished plant bug, European apple sawfly, oriental fruit moth, and stink bug were the most significant insect pests in pome and stone fruits on Long Island. These insects were responsible for an average 5.0% apple and 1.25% peach damage during the project period.

(8) Codling moth, most damaging insect in L.I fruit, damage was found less than 0.5% in the mating disruption area where as up to 23% codling moth damage was found in orchards where mating disruption was not used or properly executed. Oriental fruit moth (OFM)

damage was found, just 0.25% in apples and 0.15% in peaches in the mating disruption area. However, in the non-mating disruption blocks nearly 2.0% fruit was found damaged by OFM.

As project participating partners L.I. fruit growers have agreed to accept environmentally sustainable non-insecticidal insect mating disruption techniques in their orchards replacing the traditional insecticide based management despite the higher cost and risk associated with introducing new technology. Long Island has approximately 334 productive acres (28 acres of new planting in 2014 - 15 is not included) of tree fruits owned by 15 growers. With the support from this project, about 70% (233 acres) of the Long Island tree fruit acreage has brought under some forms of insect mating disruption program for controlling major insect damage. 18% acreages (about 60 acres) didn't have significant OFM/CM problem, so MD was not economical for these farms. Insect populations are often do not exist at the same level in an area or even in an orchard. Another 12% tree fruit blocks (about 40 acres) were not suitable for MD because of small or fragmented shape.

Goals and Outcomes Achieved

During 2014 – 2016 the project was successful for implementing about 70% of the Long Island tree fruit acreage under the non-insecticidal insect mating disruption techniques. This is about more than 3 times the acreage under mating disruption at pre-project period in 2013 (<20%). Overall, growers have reduced their insecticide use from 4 - 8 application per season to 0 – 2 application per season for controlling the insects managed by mating disruption techniques.

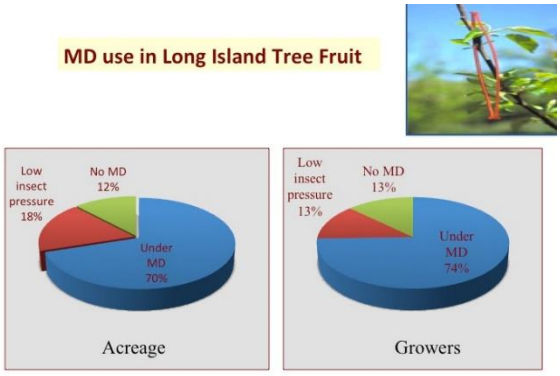

Figure 1. shows the % acreages and growers currently using the non-insecticidal mating disruption techniques in Long Island tree fruit orchards.

Knowing the pest status and population trend are keys for a successful pest management operation in any agriculture production. Production of good quality fruits and economic sustainability of orchards largely depend on timely control of the pests. Insect monitoring traps were set in each of the project participating orchards to understand the population status and

performance check. Traps were checked weekly from mid-May to September. Over the project period codling moth populations were noticeably low in mating disruption orchards than the non-mating disruption orchards (Table 1). Average 1.08, 0.20, and 0.07 codling moth/trap/week was captured from the mating disruption blocks compared to 2.47, 1.75, 2.40 codling moth/trap/week from the non-mating disruption blocks in 2014, 2015, and 2016 growing seasons, respectively. Based on tarp data we found a clear trend of decreased codling moth populations in the mating disruption area where as a steadily higher population was observed in the non-mating disruption area. Similar trends have been observed in the oriental fruit moth populations (Table 2). Peachtree borer populations were sporadic in the area and mating disruption ties were only used in the peach orchards have history of tree damage. Overall peachtree borer populations in the mating disruption area were less than 0.20/trap/week during the project period and in the non-mating disruption area the populations were also at negligible levels (based on data collected from 12 and 8 traps from MD and non-MD orchards, respectively).

Table 1: Shows the average number of codling moth/trap/week in the mating disruption and non-mating disruption apple orchards during the growing season in 2014 - 2016. Number in parenthesis are the number of traps checked in the project area.

Pest management used	2014	2015	2016
Mating disruption	1.08 (7)	0.20 (8)	0.07 (8)
Non-mating disruption	2.47 (10)	1.75 (10)	2.40 (11)

Table 2: Shows the average number of oriental fruit moth/trap/week in the mating disruption and non-mating disruption apple and peach orchards during the growing season in 2014 - 2016. Number in parenthesis are the number of traps checked in the project area.

Pest management used	2014	2015	2016
Mating disruption	1.52 (25)	0.21 (19)	0.18 (20)
Non-mating disruption	3.08 (16)	1.37 (16)	1.83 (16)

Based on weekly monitoring data growers were provided season-long pest management recommendations through weekly Fruit and Vegetable Newsletter (published by the CCE-Suffolk County), on site visit and phone contact. During the project period over 150 farm visit, meeting, email and phone calls from the tree fruit growers were responded by the project investigators. Based on the information generated from this project about 18 notes (informative articles) were published in the weekly CCE-SC Fruit and Vegetable Newsletter.

In each year Cornell Cooperative Extension of Suffolk Co. organized a two days long Annual LI Agricultural Forum meeting which is participated by over 200 stakeholders from various commodities including viticulture, tree fruits, vegetables, greenhouse/floriculture, landscape & gardening, nursery etc. There has been a general session which is participated by audiences from all commodities. Usually highlights from the important projects were displayed on an information table outside the general session conference room. The significant project outcomes were also mentioned in the general session. The outcomes of this project were displayed and mentioned in the general session. After the general session the meeting was broken into commodity based multiple session where stakeholders from specific commodities were participated. There was a tree fruit session where details of this project outcomes were presented to 37 audiences in a 40 min. power point presentation. Many of the audiences have multiple interests but they could not participate more than one session because of overlapping session period, however they were provided highlights of the project activities in the general session which was participated by the total audiences. So the number “200 specialty crop growers” is used based on total number of meeting participants. However, the actual number of tree fruit session participants were 37 (27 males, 8 females). I would rather amend that notes to “Project outcomes were shared at the annual L.I. Agricultural Forum to more than 200 participants (growers, farm workers, and other stakeholders) from various crop commodities including tree fruit growers.”

Beneficiaries

The direct beneficiaries of this project are the 7 participating tree fruit growers owns 70% (233 acres) of the tree fruit acreages on long island. Under the cost-sharing agreement fruit growers were provided 40% reimbursement of the mating disruption tie purchase costs to offset the additional expenditure of using mating disruption technique instead of using comparatively low-cost insecticides which has limited success and adverse environmental consequences. With the cost sharing support participating growers have directly saved an average $53.2 and $32.4 per acre for purchasing mating disruption ties for apples and peaches, respectively. Over the project period (2014 – 2016) a total of $29,936.85 has been directly reimbursed to the participating growers. In addition mating disruption users applied 2 – 6 less insecticide applications per season than the conventional insecticide users or pre-project period management scheme. By using less insecticide, mating disruption users have saved approximately $124 – $372 per acre in each season depending on insect pressure and fruit commodities. Cost-sharing support also motivated and encouraged growers using mating disruption techniques for the long-run beyond the project period.

The indirect beneficiaries are the thousands of tourist, U-pickers, consumers as well as Long Island environment. Growers who has adopted mating disruption techniques have used two to six fewer insecticide applications in their orchards. Most older and less environmentally compatible pesticides have been replaced with reduced-risk alternatives and applications are being made more in response to actual threats, than preventively. Currently 75% of insecticide used in LI fruit orchards are EPA-designated reduced-risk materials. Long Island agriculture, and orchards in particular, are an important component of the local economy including tourism. Growers are especially interested in minimizing insecticide sprays during summer or near to harvest, in orchards located near surface water, or in areas where groundwater is close to the surface.

Yearly pre-harvest fruit evaluation (for insect damage only) helped extension educators and growers understanding the current economic threshold and deciding future pest management goals.

Lessons Learned

Because many of the Long Island fruit orchards are U-pick (pick your own) operations, consumers often saw the mating disruption ties on trees and have learned that there are pest management techniques in place other than direct insecticide spray. On-site learning about non-insecticidal pest management options encouraged consumers visiting farms frequently and buying more safer fruits. As a result of increased demand local pesticide dealers are now keeping mating disruption ties in their inventory which was previously limited to only insecticide options.

Because mating disruption technology is new to majority of the Long Island fruit growers, it is necessary to provide continuous expert support so that growers/workers can maintain appropriate use of this technology such as proper rate, timing, placement, performance check etc.

As mentioned in the goal and outcome section the project was successful for implementing about 70% tree fruit acerages under mating disruption. Some of the 30% tree fruit blocks were not suitable for MD because of small and fragmented shape or the insect populations were low in the area but these orchards could be brought under mating disruption if the insect pressure change and growers increased the orchards size in future (minimum of 5 acres).

Additional Information

Publication:

Faruque Zaman, Laurie McBride, and Dan Gilrein, May 2014, Insect Mating Disruption: A Non-Insecticidal Pest Control Technique in Orchards, Agricultural News, Cornell Cooperative Extension of Suffolk Co. Vol 98, Number 5. Pp 5-6.

Workshop:

Workshop on “Insect Mating Disruption Techniques in Orchards”. April 23, 2014. Cornell

Cooperative Extension of Suffolk County, Riverhead, NY 11901. – 12 attendees

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Project 9 (FINAL)
Northern NY Specialty Crop Project

Project Summary

The overall purpose of this project was to increase demand from consumers for local specialty crops thus driving farmers to produce more. The issues are that farmers need more sales outlets for and consumers need more access to local sources of specialty crops. We proposed to tackle this problem with a three-pronged project: food hub economic evaluation, Adirondack Harvest membership campaign, and educational classes and public service announcements for farmers and consumers.

The "buy local" movement continues to have plenty of momentum, and specialty crop farmers in the North Country continue to strive to find markets for local fruits and vegetables to increase their income. Consumers continue to gain awareness of local produce, but there is much work to be done to increase their spending at farms and farmers' markets. There is also tremendous potential within the restaurant industry in the Adirondack region to increase purchase and use of local specialty crops especially in the summer when these crops are available. The biggest barrier is the lack of a feasible and efficient distribution system for locally produced food. We set out to determine if the farms of Northern New York were interested in forming "food hubs", defined as "a business or organization that actively manages the aggregation, distribution, and marketing of source-identified food products primarily from local and regional producers in order to satisfy wholesale, retail, and institutional demand."

The Adirondack Harvest membership campaign sought to reach out to specialty crop farmers, stores and restaurants who were not previously associated with our organization. Our goal was to highlight the benefits of branding for direct marketers of New York specialty crops, again increasing everyone's bottom line.

Education is always needed and is a core component of Cornell Cooperative Extension. We felt that farmers and consumers could use training in how to grow, sell, market, find and purchase local specialty crops. The low income population is often the least well-informed about healthy eating, cooking and purchasing fruits and vegetables. Our public service announcements were designed to target the low income population and encourage use of SNAP benefits at farmers markets.

This project was partially built on a previously funded project with the SCBGP, the Regional "Buy Local" Campaign Development. Adirondack Harvest received one of these grants to expand our membership and develop the already established Adirondack Harvest buy local campaign. Some of the promotional materials we created in that previous grant were funded further in this current SCBGP grant.

Project Approach

- We organized and implemented two Farm to Chef Workshops in Plattsburgh (3/10/14 and 2/9/15) with CCE Clinton County to encourage more local food use in regional restaurants. This

was held as part of our work plan to hold classes on branding and promotion of specialty crops (a total of 30 participants). Many farmer chef connections were made but neither was as well attended as hoped. For whatever reason, many chefs don't have the time to attend events such as these. The ones who did attend, however, were very enthusiastic and continue to purchase specialty crops from the local farmers who were also at the event.

- During the course of this grant, 11 local food guides were produced covering Clinton, Essex, Franklin, Jefferson, Lewis, St. Lawrence, Warren, Washington, and Saratoga counties. Both specialty crop and non-SC producers were listed along with farmers markets, stores and restaurants. We worked closely with CCE agents from all of these counties to produce these guides. In total, nearly 150,000 guides were printed and distributed, and the pdf versions remain available for viewing on the Adirondack Harvest website at http://www.adirondackharvest.com/guides.html (although the Warren/Washington/Saratoga guide is still in the final design stages and has not been printed yet – that will be posted on the website as soon as possible). A significant result of our food guide research and production was an education by GardenShare, in St. Lawrence County, for 8 Extension educators about how to produce financially sustainable guides in the future by soliciting advertising funds and finding sponsors, thus hopefully eliminating the need for grant funds to support the food guides in the future. Public reception of the food guides is invariably positive and our office frequently receives requests from businesses and libraries to restock their supplies. Informal reports from farmers indicate that consumers are successfully locating them and purchasing more due to the presence of the food guides. All non-SC portions of the food guides were supported by Northern NY Agricultural Development Program funding.

- We arranged for airing of public service announcements on major television stations in Plattsburgh and Watertown, effectively reaching both the eastern and western regions of Northern NY. Here is the breakdown of the airings:
    - Fox28 WNYF Watertown: 151 spots (aired 7/28/14 to 10/26/14)
    - Channel 7 WWNY Watertown: 67 spots (aired 7/28/14 to 10/24/14)
    - News Channel 5 WPTZ Plattsburgh: 96 spots (aired 9/1/14 to 10/31/14)
    - News Channel 5 WPTZ-CW Plattsburgh: 50 spots (aired 9/1/14 to 10/31/14)

  Possible households reached in the Plattsburgh region: approximately 89,000 per airing. Possible people reached in the Watertown region: approximately 244,000 per airing. The PSAs had been previously produced by CCE Jefferson County and focused on education to adopt healthy eating habits by purchasing fresh fruits and vegetables. It encouraged organizations to set up fruit and vegetable vending machines, and low income families to use their Farmers Market Nutrition Program coupons and SNAP benefits to purchase these specialty crops at their local farmers markets. We did hear from many people who saw these PSAs and responded favorably to the message. There is a great need for more education about the use of FMNP coupons, SNAP benefits and WIC-VF coupons at the farmers markets as statistics indicate a large portion of these benefits go unused each year. This represents a significant loss of income for specialty crop farmers who accept these benefits, and of course the consumers are missing out on nutritious food. The feasibility of this aspect of the grant project lay in the fact that the PSA was already produced and we only needed funding for the airtime.

- The Food Hub economic impact study, An Analysis of Opportunities for Food Hub Development in Northern New York, was comprised of several components:

- Executive summary, which is set up to be used by local businesses and economic development people to use in make decisions on where and how to set up local food hubs.
- Methods used
- Description of area
- Analysis of the Farmer opinions and likelihood of expanding
- Analysis of the Commercial Buyer opinions and likelihood of buying more
- Analysis of the Consumer opinions and likelihood of buying more
- The current marketing channels and resources were identified and evaluated.
- Alternative marketing strategies were identified and evaluated.
- Specialty crop stakeholders (farmers, consumers, restaurants, stores, processors and delivery systems) were interviewed for the survey in all six Northern NY counties.
    - Our goal was to survey 125 specialty crop farmers. The actual number of specialty crop farmers surveyed was 89.
    - Our goal was to survey 27 restaurants and stores. The actual number of restaurants and stores surveyed was 24.
    - Our goal was to survey 100 consumers from the 427,000 residents. The actual number of consumers surveyed was 254.
    - Our goal was to survey 20 processors. The actual number of processors surveyed was 15.
    - Our goal was to survey 6 farmer cooperatives. The actual number of farmer cooperatives surveyed was 3.
    - Our goal was to survey 6 delivery systems. The actual number of delivery systems surveyed was 7.
    - It was extremely difficult to get participants as the survey was very long and took over an hour to complete. We had more participants on the Easterly side of the region. A lot depended on the Extension Association and how eager they were for input on food hubs.
- The project results and significant findings were presented at the CCE Agricultural In-service direct marketing training (45) and the NYS Direct Marketing Conference (52). These are professionals that may use the information in their work.
- Survey data was analyzed by the Cornell Dyson School of Economics
- The literature review was conducted, and added to the Guidelines.
- Regional meetings were held in Lake Placid and Watertown to review the data analysis from the food hub surveys and the draft Guidelines and gather additional information to include in the report.
- A full report of the survey analysis was produced by Cornell University. The results have been presented to:
    - The food hub feasibility study results and options were presented to:
    - The Adirondack Harvest membership at their annual meeting on January 14, 2016. 35 members reached.
    - A meeting of the Northern NY Ag Development Program on February 5 in Chazy, NY to cover the eastern region.
    - A second meeting of the Northern NY Ag Development Program on February 12 in Watertown, NY to cover the western region. This meeting was broadcast via radio and television.

        - A meeting in Keeseville, NY where a new farmer group with two specialty crop farmers was working on forming a food hub in that town.
    - A shorter summary report with guidelines was produced through a joint effort by Cornell University and CCE Essex County.

- An Adirondack Harvest membership campaign was conducted during the past two years with extensive outreach to the Northern NY region as well as several of the southern counties in the Adirondacks. Our goal was to gain membership in our regional branding program, helping specialty crop farmers to reach more customers, selling more fruits, vegetables, honey, maple and other specialty crops. Over the entire grant period, we added 15 new stores & restaurants (our goal was 10) and we added 14 new specialty crop farmers to Adirondack Harvest (our goal was 20). We used grant funds to produce membership brochures that were distributed throughout the counties and also left with CCE extension agents for future promotion. We were encouraged by the many new members, most of them from the Eastern Northern NY region. The western region continues to be problematic in their resistance to joining Adirondack Harvest. We think this is because they relate more closely to the St. Lawrence Seaway region instead of the Adirondack region. Plus, the central office of Adirondack Harvest is in Essex County, so the most activity and excitement around this organization is focused on the eastern counties. We had hoped to gain more members in the west, but at the conclusion of this grant have decided that perhaps the western counties should develop their own identifying brand. Our new Harvest NY specialist, Lindsey Pashow, is working on developing a St. Lawrence Seaway identity in the future. However, the Warren, Saratoga, and Washington Counties are very interested in working with Adirondack Harvest and we have gained several members and brand recognition in that region. Teresa Whalen, a community volunteer got excited about a Local Food guide and is leading the Southern Adirondack chapter of Adirondack Harvest.

- Various promotional materials were produced for our specialty crop farmers to display and use for their businesses. These materials included:
    - Durable, waterproof “member of Adirondack Harvest” signs for display at roadside stands, on barns, etc.
    - “Price cards” with the Adirondack Harvest logo. These are used to let Adirondack Harvest members label their products and individualize prices.
    - Small adhesive labels for specialty crop farmers to use on their products.
    - Farmers markets “directional” signs to help promote the markets, with wording that highlighted fruits and vegetables.
    - Adirondack Harvest “caps”. These are baseball-style work caps that are very popular with our members and customers. The Adirondack Harvest logo is colorful and attractive and the cap is well made and comfortable. We have distributed the caps to our specialty crop farmer members.

  The goal of all these promotional materials is to increase brand recognition and thus sales of specialty crops. Consumers recognize the logo and know that the farmers are local and raising fruits and vegetables in the Adirondack region. We worked closely with each county’s CCE office to make sure the materials were delivered specifically to Adirondack Harvest farmers who were growing specialty crops.

- We held regional pre-season market trainings in March and April of 2015 to educate farmers in the complexities of working with EBT/SNAP, FMNP and WIC coupons/checks/cards.

Comprehensive handouts were made available to educate farmers on the different programs and how they could sign up for the programs. The focus was on how the farmers could increase their sales of specialty crops by accepting these low-income consumer checks and cards. All the Northern NY CCE offices cooperated in setting up these trainings, inviting farmers to attend and providing training space. Several farmers who previously had not been accepting these benefits at their farmers market booths felt more comfortable about working with them and have since applied to be part of these programs. All of these are critical to the task of increasing consumption of fruits and vegetables in low-income households. At the Pre-season classes we also held a program on branding farm products. Branding is more important as the farm grows, and there is less time to talk individually to costumers.

- Classes on business and cooperative structures as strategy for food marketing and delivery were held in Plattsburgh and Burrville on April 9th. Bobbie Severson led the classes and there were 10 participants in Plattsburgh and 15 participants in Burrville. The handout is in the Appendix of the Guidelines. We have had several additional individual discussions with interests in working together (10).

- Consumer cooking and preservation classes were held in Essex, Clinton, Lewis and Jefferson counties. All of these classes provided essential education to consumers with renewed interest in using more fruits and vegetables in their meal planning and overall diet.
    - In Essex County a consumer cooking class was held featuring varied ways to prepare locally produced specialty crops and was taught by well-known local chef, David Hunt. Dave specializes in sourcing locally for the ingredients at his restaurant in Wilmington. 21 people attended this 2 hour class focusing on vegetables available at local farms.
    - Also in Essex County we held a canning and preservation class focusing on specialty crops. This was held during a "Farm and Family Day" during which about 25 people gained training and information.
    - In Lewis County a canning/preserving class was held focusing on making salsa with all local ingredients. The participants were all completely new to canning so the instructors felt like the class was valuable
    - Also in Lewis County they hired a BOCES instructor to teach a double-session cooking class using winter storage crops such as squash, turnips and parsnips. Local honey was used to make homemade salad dressings and local maple was turned into maple candy. 30 people attended this event which was held at the American Maple Museum in Croghan, NY.
    - In Jefferson County a pressure canning class was held to teach the basics of canning low-acid foods safely to preserve the local harvest. Participants received a hands-on demo of canning green beans from start to finish as well as resource information on canning food safety. All participants also received a Ball Canning Guide and were able to take a home a jar of freshly canned green beans the next day. There were 11 participants
    - In Jefferson County a "Healthy Cooking" class was held to teach traditional New Orleans recipes with a healthy twist using local foods such as peppers, tomatoes and sweet potatoes. The 14 participants sampled recipes and received a recipe booklet.
    - In Clinton County a cooking class was offered for kids (7 youth and 4 adults attended). CCE staff taught the youth how to make 5 different dishes using local ingredients: apple & squash bake, mini veggie pizzas, carrot & beet salad, kale salad, baked potato with toppings. Each youth gained confidence rinsing produce, using peelers, knives, graters and other kitchen equipment and familiarity with a variety of vegetables. The

vegetables were sourced locally and provided the youth with an opportunity to taste multicolored carrots, potatoes, and eat some less familiar foods like kale and beets. "Can we do this again?" one boy asked; his mother expressed interest in more cooking classes and offered to volunteer in any way she could. The entire group became involved in this conversation and all expressed interest in future cooking classes. "I would give this 5 stars!" said one little girl about the apple and squash dish, even though her mother reported she's never enjoyed squash previously. She even went so far as to make this dish for Thanksgiving. "I have never seen a purple potato. It tastes good!" One child said about the potatoes at the potato bar. "I like the sweet potatoes the best", another girl noted about the potato bar. Because of the success of this event (more had signed up, but it was cold/flu season), more classes will be offered in the future, coordinating to the EFNEP, 4-H and local food educators.

- The final activity performed, which was a welcome outcome of our work for the previous two years, was working with a newly developing food hub in the town of Essex, "The Hub on the Hill". Several local farmers banded together, met with many other local farms, and decided to form this food hub. We were able to share our survey results with them, provide technical support, and help with funding for informational promo cards, marketing signage for their specialty crop cooperative members and for educational classes regarding food preservation, food safety and processing. This food hub has 26 total producers, 12 of whom are specialty crop farmers. The creation of this food hub will increase the potential of these producers to grow and supply specialty crops to the North Country of NY and beyond. The hub and CCE Essex are currently developing a delivery system for Adirondack Harvest members which will help alleviate the stress of distribution for them.

Goals and Outcomes Achieved

- 2 Farm to Chef Workshops held. This met our goal of holding two classes connecting farmers and chefs during the grant period

- 11 local food guides were produced covering Clinton, Essex, Franklin, Jefferson, Lewis, St. Lawrence, Warren, Washington and Saratoga counties. Over 150,000 guides were printed. Our goal had been to produce 12 guides (6 counties x 2 years), but Franklin and Clinton combined with Essex County to form a tri-county guide for both years. Essex County also produced a solo food guide, so in reality, the six Northern NY counties produced 10 guides. However, we were also able to create a food guide in the Southern Adirondack counties of Warren/Washington/Saratoga. This was a region that had not had a local food and farm guide for many years. We feel that we not only achieved our performance goals, but exceeded them with the inclusion of the Southern Adirondack Harvest region.

- Our PSA was aired 364 times during the late summer and fall of 2014. Our goal was to reach "millions" of consumers with 300 airings of the PSAs and that goal was met. Using the demographic information provided by the television stations, we calculate that a possible 1.3 million people (average 4 people per household) may have viewed the PSAs' message of using more fruits and vegetables in snacks and home cooking.

- Food Hub economic impact study, An Analysis of Opportunities for Food Hub Development in Northern New York, activities completed and in progress:
    - The current marketing channels and resources and alternative marketing strategies were identified and evaluated.
    - Survey tools were developed in conjunction with the Cornell Dyson School of Economics and specialty crop stakeholders (farmers, consumers, restaurants, stores, processors and delivery systems) were interviewed for the survey in all six Northern NY counties.
        - Our goal was to survey 125 specialty crop farmers. The actual number of specialty crop farmers surveyed was 89.
        - Our goal was to survey 27 restaurants and stores. The actual number of restaurants and stores surveyed was 24.
        - Our goal was to survey 100 consumers from the 427,000 residents. The actual number of consumers surveyed was 254.
        - Our goal was to survey 20 processors. The actual number of processors surveyed was 15.
        - Our goal was to survey 6 farmer cooperatives. The actual number of farmer cooperatives surveyed was 3.
        - Our goal was to survey 6 delivery systems. The actual number of delivery systems surveyed was 7.
    - Raw data was presented to many stakeholders and the data was analyzed by Cornell as was our goal.
    - Analyzed results have been presented to agricultural development programs and other stakeholder meetings as was our goal.
    - A shorter summary report with guidelines was produced through a joint effort by Cornell University and CCE Essex County. This evaluation summary developed potential solutions to address the delivery problem for our specialty crop farmers as was our goal.
    - Reber Rock Farm, a processor, decided to add value to many specialty crops, including carrots, green beans and tomatoes, by pickling and/or canning them and using the Wholeshare ordering and delivery system (our goal was one processor)
    - At least 12 specialty crop farmers (along with about 14 non-specialty crop producers. Our goal had been 25 specialty crop farmers) in the Champlain Valley are in the process of forming a cooperative delivery system at the newly formed food hub, “Hub on the Hill” and will be using the Wholeshare ordering and delivery system to ship their products.

- An Adirondack Harvest membership campaign was conducted. We added 15 new stores & restaurants (our goal was 10) and we added 14 new specialty crop farmers to Adirondack Harvest (our goal was 20). We continue our membership campaign, constantly reaching out to potential new members. One activity associated with the membership campaign was to produce 1000 membership brochures for distribution across the Adirondacks, which we did.

- Promotional materials were produced for our specialty crop farmers to display and use for their businesses using Adirondack Harvest logo and approved specialty crop wording. All goals were met for this activity:
    - 100 Durable, waterproof “member of Adirondack Harvest” signs.
    - 20,000 “Price cards”.
    - 60,000 Small adhesive labels.

- 120 Farmers markets “directional” signs.
- 70 Adirondack Harvest “caps”.

- 18 educational classes were held/attended and there were 202 participants (our goal was a minimum of 12 classes and 100 participants total)
  - 3 regional trainings to educate farmers on EBT/SNAP, FMNP and WIC benefits (31 participants).
  - 3 regional classes discussing branding and promotion of specialty crops, in conjunction with our Adirondack Harvest membership campaign (26 participants).
  - 2 classes on business and cooperative structures as strategy for food marketing and delivery (25 Participants).
  - 1 consumer cooking class in Essex County was held (21 participants).
  - 1 canning and preservation class in Essex County was held (25 participants).
  - 1 canning/preserving class was held in Lewis County (2 participants).
  - 1 cooking class was held in Lewis County (30 participants).
  - 1 canning/preserving class was held in Jefferson County (11 Participants).
  - 1 cooking class was held in Jefferson County (14 Participants).
  - 1 cooking class was held in Clinton County (11 participants).
  - 3 classes on food preservation, safety and processing were attended by food processors at the new food hub in Essex (6 participants).

- While the creation of a new food hub in our region had not been a goal or activity in our work plan, we are happy to report that we worked closely with the entrepreneurs who have started the “Hub on the Hill” in Essex, NY. We had several meetings with them, sharing the survey results and discussing options for collaboration with other farms and businesses as well as promoting the Adirondack Harvest brand through a newly forming delivery system. Also, Jefferson County has secured funding to build a Food Hub to market excess specialty crops in Watertown. They are using our An Analysis of Opportunities for Food Hub Development in Northern New York, guidelines to help develop their plan.

Beneficiaries

The intended beneficiaries of this project’s accomplishments are:

- Northern NY specialty crop producers.
  - Our goal was that they would benefit from increased sales due to the marketing materials and branding associated with Adirondack Harvest.
  - Even specialty crop farmers who were not AH members were expected to benefit from such promotions as the public service announcements, the local food guides, consumer educational classes, and farmers markets signs.
  - The food hub economic study is expected to benefit all specialty crop farmers as we move forward to help establish distribution centers and delivery systems. It will also benefit the North Country Economic Development Council, bankers a farmers planning on investing in Food Hubs to have the information on what types of activities can be done, where and how far apart, what the farmers want and what the buyers want, and

- Buyers & consumers of these specialty crops such as stores, restaurants and the direct market public. Education of these consumers about how to find and cook with these items increases their demand for ingredients. Easy access to and delivery of quantities of local specialty crops can be solved with cooperative food hubs.

We did not state, in our goals, that we would track increased specialty crop sales as a measurable outcome. By promoting specialty crops and local delivery systems, our goal is to eventually increase sales by 10% which could translate to $720,000 for the region's producers (based on 2007 census data indicating the value of specialty crop sales in our region to be about $7.2 million annually). We will evaluate this when the new census data becomes available.

Lessons Learned

- The Farm to Chef workshop formats were not as productive and well attended as we had hoped. Since the grant ended, we have not tried to hold another workshop with farmers and chefs, but we are talking with some of our local chefs as well as Extension agents in Jefferson County who have ideas about how to attract more participants, including different venues and more publicity of the event. Time of day or even day of the week may have been a factor. In preparing for Farm to Chef events it would pay to check in with many restaurants to find out the best approach, what works for them, as the farmers are generally flexible.

- Our 11 local food guides were very successful and well received by consumers. The result of these publications is always positive and feedback from farmers indicate that the public is indeed using these guides to find local food. It was a fortunate unexpected outcome that we were able to provide funding for a local food guide in the southern county region of Adirondack Harvest. All counties were able to learn about how to sustainably fund future guides through the solicitation of advertisers and sponsorships. This is an important lesson for any region that would like to publish such a useful guide but may not have any grant opportunities. However, the publications are so desirable that we could use our newly acquired skills in using advertising to print the guides.

- While interviewing farmers for the food hub economic impact study, we learned that many farmers, while they do want to boost sales, do not want to spend time filling out surveys, understandably.

- The major lessons we learned from the food hub study are explained in the attached, An Analysis of Opportunities for Food Hub Development in Northern New York, publication.

- Our Adirondack Harvest membership campaign fell short with adding new specialty crop farmers (only 14 new members – our goal was 20) but came out ahead with stores

and restaurant recruitment (15 new members – our goal was 10). In point of fact, we had at least 20 new farmer members, but only 14 were purely specialty crop farmers. Most of the new farmer members are from the Eastern Northern NY region. The western region continues to be problematic in their resistance to joining Adirondack Harvest. We think this is because they relate more closely to the St. Lawrence Seaway region instead of the Adirondack region. Plus, the central office of Adirondack Harvest is in Essex County, so the most activity and excitement around this organization is focused on the eastern counties. We had hoped to gain more members in the west, but at the conclusion of this grant have decided that perhaps the western counties must develop their own identifying brand.

- Classes to help market farmers feel more comfortable accepting and working with EBT/SNAP, FMNP and WIC-VF coupons/checks/cards were well attended, and that was encouraging, but there is still much resistance to anything that requires extra work and training. While the WIC-VF checks are becoming a bit easier to use, they are still relatively cumbersome for the farmer to process and remember how to fill everything out. Hopefully in the future there can be an easier system. Easier to use system = more farmers using it = more WIC-VF checks used = more fruits and vegetables purchased!

- The two classes on business and cooperative structures classes have not produced any new cooperatives, corporations, or partnerships that we know of. However, there are several private farmers that have set up systems to add value to foods through processing, branding/labeling, marketing through new channels, and/or coordinated deliveries. For smaller operations it is easier to keep the transactions and decision making clean with a private entrepreneur in charge. The investments have not been too large to need a group of people to join together. We have helped the Adirondack Grazers increase their number of investors from Northern NY.

- We were happy to see that there is still much public interest in cooking, canning and preserving classes. With the surge in CSAs, farmers markets and farm stands, more consumers are eager to learn or re-learn how to make the most of their specialty crop purchases. We would encourage other organizations to continue to offer regular classes on these topics as all three are essentially lost arts.

- Our biggest unexpected outcome was the formation of the new food hub in Essex. While we had hoped that some food hubs would develop in the Northern NY region, we were excited to see one moving ahead fairly quickly. We were able to provide support and education for them, using the results of the survey study and we continue to work with them to develop their marketing and outreach. Within this outcome, 1 existing delivery system (Wholeshare) is in the process of adding Adirondack Harvest members to their current delivery route and operating through this food hub.

- We have several unexpected results from this project that show the impact we have had in the region.
    - The CCE Essex office and Board President, Jay White, started working on an Adirondack Cuisine Trail in Essex County. When our neighboring counties found out about this they were very interested as well, so we have gone to each County Board of Supervisors/Legislators to discuss the concept. It has been overwhelmingly accepted. We continue to set up the Farmer Cooperative and application to NYSDAM.
    - The 6 counties Clinton, Essex, Franklin, Jefferson, Lewis and St. Lawrence have signed contracts for a Regional Agriculture Program that includes specialists for direct marketing of: for Specialty Crops, Lindsey Pashow; for Meats, Mackenzie Waro; and for Dairy, Anika Zuber. Essex and Clinton also have Regional Specialist in production: Small Fruits and Vegetables, Amy Ivy; Apples and Grapes, Anna Wallis; and various others covering horticultural products, and business.
    - Just last month we were awarded $75,000 from DEC for the Adirondack Smart Growth program to modernize the Adirondack Harvest website to make it more user friendly and Smart Phone compatible. We will be adding forest products to our list of products harvested locally, as well as adding pages for Community Supported Agriculture farms, Processors, and the Cuisine Trail for Clinton, Essex and Franklin Co (possibly Lewis Co, too)

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Project 10 (FINAL)
Evaluation of Grape and Wine Production Practices in Support Of the Emerging Cold-Hardy 'Northern Grapes' Industry in New York

Project Summary

Four new grape varieties, Frontenac, Frontenac gris, La Crescent, and Marquette, form the basis for a new wine industry developing in both the Thousand Islands (near Watertown) and upper Hudson Valley (near Lake Champlain) regions. To date, these cultivars support at least 48 wineries in northern New York. They also provide a new option for potential growers and wineries in other parts of New York, such as Cooperstown, Cazenovia, the Mohawk Valley and higher elevation sites in the Hudson Valley and western New York. This project continued viticulture and winemaking trials started in 2012 that addressed production issues associated with these cultivars, and provided outreach to new growers producing these grapes and wines.

These new cold-hardy cultivars, developed in Minnesota and released between 1997 and 2006, combine good wine quality with the ability to survive winter temperatures as low as -30° F. They also have characteristics that set them apart from traditional hybrid and *vinifera* grapes grown in the Finger Lakes region. Their parentage includes wild *Vitis riparia*, which gives them a different growth habit and juice composition than more traditional wine grape varieties. At harvest, these cultivars end up with both relatively high titratable acidity and high sugar content. Grape production and winemaking practices adapted to these cultivars and their unique characteristics are needed to support continued growth and viability of this new industry.

Expansion of grape and wine production into non-traditional areas has also created a need for continued education and extension to new growers and winemakers. Unlike startup operations in established areas (e.g. Finger Lakes), growers and wineries in non-traditional areas have no network of established producers to draw upon in their regions.

We established the 12-state Northern Grapes Project, designed as a five-year Specialty Crops Research Initiative (SCRI) Coordinated Agriculture Project (CAP), and secured funding through USDA for the first two years of the project (Sept 2011-Sept 2013). Our objectives were to address in a coordinated fashion grape production (viticulture), winemaking (enology) and economics/marketing to support production and sales of quality wines from Northern Grape cultivars, and to convert these startup enterprises into sustainable businesses positioned for further growth and development. This Specialty Crop Block Grant provided funding to bridge a "gap year" in funding from the SCRI program, to allow us to continue research at Cornell and continue the Northern Grapes Project Webinar Series. As an outcome of this 'gap year' funding, we successfully submitted a renewal project to fund the fourth and fifth years of the Northern Grapes Project with the USDA Specialty Crops Research Initiative.

Project Approach

We asked for support during the 2014 growing and winemaking season to enable us to continue field, winemaking, and production cost studies in New York. Our objectives were:

1. *Continue the 3rd year of training system and crop level studies underway at Coyote Moon Vineyards near Clayton New York.*

In 2012, we established three training systems in Marquette and Frontenac grapes; we evaluated Top Wire Cordon (TWC), Umbrella Kniffin (UK), and Midwire Cordon with Vertical Shoot

Positioning (VSP). Additional cluster thinning and cropping level studies were planned in La Crescent and Frontenac. We collected data on production, phenology, winter injury, fruit composition, and costs.

The winter of 2013/2014 was extremely cold, resulting in widespread winter injury to vines. We were able to successfully collect data in the training systems studies, but were not able to continue the crop level studies, as very little crop was present in both La Crescent and Frontenac. We also learned that at this site, Frontenac vines handled the extreme low temperatures with little to no trunk damage, but had extensive bud damage, resulting in yield of less than one-half ton/acre. Conversely, Marquette had less bud damage than Frontenac, with yields of 2.5 to 3 tons/acre (about half of a "normal" crop), but many trunks were damaged during winter, leading to crown gall infection and vine collapse during the summer. In both Frontenac and Marquette, there was little difference in fruit chemistry among treatments at harvest.

The winter of 2014/2015 was not nearly as cold, but a severe late spring frost on May 22/23 caused over 95% "first crop" shoot loss, but there was good emergence of "second crop" shoots. Therefore, we were once again unable to conduct crop load studies in La Crescent and Frontenac. In the training system studies, we tagged all "first crop" shoots (those that survived the frost event), and tracked the fruit chemistry of "first crop" and "second crop" fruit from veraison to harvest. We also collected yield data in Frontenac, keeping separate the "first crop" and "second crop." Many Marquette vines were still suffering the effects of trunk damage from the 2013/2014 winter, making it impossible to collect to yield data. Results indicated that "second crop" fruit chemistry lagged well behind the "first crop," but differences between the two crops became less as ripening progressed. Also, second crop fruit in Marquette seemed to "catch up" better than Frontenac, as the difference between soluble solids and total acidity in the first and second crops was smaller. In Frontenac, "first crop" yield was overall quite small, and there were no differences in yield among training systems. However, for the "second crop," yield was significantly higher in TWC than VSP and UK, as there was a higher number of "second crop" shoots. There was no differences in fruit chemistry among training systems.

2. *Continue yeast strain evaluation for major Northern Grapes cultivars.*

Choice of yeast strain has a strong influence on resulting wine attributes, including flavors and mouthfeel. We had planned to evaluate three different strains for each of the four cultivars through small-scale duplicate fermentations and sensory analysis; however, extreme winter temperatures in most participating research vineyards limited fruit production, making yeast trials impossible. Instead, fruit from variety trials were used for trials of indigenous yeast nutrient. Yeast assimilable nitrogen (YAN) was measured in all cultivars, then adjusted upward at regular intervals to assess the impact of nutrient levels on wine aroma and flavor.

3. *Establish cost of production estimates and benchmarks for small scale vineyards and Northern Grape cultivars.*

We conducted Cost of Establishment and Production of Cold Hardy Grapes in the Thousand Islands and Chautauqua-Lake Erie Region for 2015, for the varieties Brianna, La Crescent, Frontenac, and Marquette. We found that Marquette may be the most profitable variety among cold hardy hybrids, but markets for these grapes are still small so this may change as the area planted to cold hardy cultivars increases. We also found substantial differences in costs of establishment and operations between the two regions. The Lake Erie regions exhibits lower establishment and operational costs due to economies of scale associated with synergies between cold hardy wine grape production and grapes produced for juice. However, these differences are expected to decrease over time, as grape production in the

Thousand Islands regions expands. A possible future scenario is that the Lake Erie region becomes the source of supply for other regions producing wine from cold hardy varieties in New York State. We calculated break even prices and yields for each variety in each region to guide planting and pricing decisions of wine-grape supply chain member and increase coordination along the chain.

4. *Continue outreach through the Northern Grapes Webinar series and associated vineyard and winery workshops.*

Northern Grapes Project Webinars are scheduled monthly during the winter season, and deliver timely information on production, winemaking, and marketing topics to an audience across New York and other states currently in the *Northern Grapes Project*. We continued this series during 2013-2015 to provide education to the Northern Grapes clientele in New York and other states

Goals and Outcomes Achieved

1. Overall, the results of the training systems studies show that TWC is likely a better choice of training system than VSP or UK, given that TWC requires less labor to prune and train than either UK or VSP, and results in higher yield with no impact in fruit chemistry.
2. Wines will be evaluated by a panel of stakeholders for difference and preference at a meeting scheduled in February 2016.

   Wines were evaluated at the 2016 Cold Climate Conference by conference attendees – data were collected, but analysis is pending.

3. We are writing two extension bulletins (one for each region) summarizing with the details of the cost studies. We will present the findings at the 2015 Agriculture In-Service Conference and at the 2016 B.E.V. Conference.

   Graduate students Sogol Kananizadeh and Dayea Oh presented the findings of this work at the 2015 Agricultural In-Service Conference in Ithaca, NY on November 4, 2016. The 2016 B.E.V. Conference has not yet taken place. Extension bulletins are still in progress, but an article was written in Vol 5, Issue 1 of the *Northern Grapes News* (http://northerngrapesproject.org/wp-content/uploads/2016/02/NG-News-Vol5-I14-Feb2016.pdf), as was a research report, which was included in the *Year 4 Northern Grapes Project Progress Report* (http://northerngrapesproject.org/wp-content/uploads/2016/02/Cost-of-vineyard-establishment-and-operation-Year-4.pdf).

4. Twelve webinars were delivered from November 2013 through April 2015 to a total audience of over 1,475 persons. Topics included trellis design and construction, emerging cold-hardy grape cultivars, planning for future growth and investment in vineyards and wineries, winery collaboration, tannin management in red cold-hardy hybrid wines, and yeast assimilable nitrogen.

   Post-webinar surveys showed that viewers are satisfied with the series. When asked if the logistics of the webinar were satisfactory, 90% of respondents agreed or strongly agreed. Participants also indicated that they're finding the series to be educational: an average of 84% said their awareness and 80% said their knowledge of the subjects increased at a moderate or

higher level. The total value of the first four seasons of the *Northern Grapes Project* Webinar Series (which includes webinars presented outside the time of this grant, for a total of 24 webinars), based on two models and a survey of webinar participants, was estimated to be $3,043,671.34. Of note, the survey results indicated that the webinar series enhanced participant economic bottom line by over $1,000 each, and that the perceived value of the series, in terms of how much participants would pay to access webinars, is over $175,000.

Beneficiaries

Since the early 2000s, we estimated that there were 200-250 acres of cold-hardy wine grapes were planted by around 100 growers in areas outside of traditional NY grape production regions, and 48 wineries in counties north of I-90 from Syracuse to Albany. The data generated by these projects impacts both existing and new vineyards and wineries, as it provides them with information to help make their operations sustainable and successful. In 2016, we will conduct a follow-up to the initial 2012 survey to estimate industry growth and development in the 5 years that were encompassed by the *Northern Grapes Project* and this NYSDAM Specialty Crops Block Grant (2013-2015)

Outreach efforts in 2013 and 2014:

- Northern Grapes Webinars – 6 annually (835 live attendees in 2014-2015)
- Northern Grapes News – 4 annual issues, 6 articles per issue (3460 recipients across 12 states)
- Northern Grapes Symposium in Syracuse: 480 in audience, 9 presentations by 14 project members.
- Northern Grapes Website: 10,000 sessions by 6,400 users in 2014-2015

Number of beneficiaries:

Our aggregate audience for outreach efforts (webinars, newsletter, winter meetings, News You Can Use, field meetings) is 3,460, across 12 different states.

We estimate, based on survey responses that 10 % of webinar attendees were from New York.

Thus the NY audience = 84.

Potential Economic Impact:

Economic impact is a little more difficult to assess, as our project spans several grape production, winemaking, and marketing topics.

- *Training studies* **--** Our data showed that 'High Cordon' training system would produce 50-100% more than the standard 'Mid-wire cordon with Vertical Shoot Positioning' used by many growers. On the 300 acres of 'Northern Grapes' estimated in New York, that would amount to an additional 600 T of grapes @ $1200/ton = $720,000.
- *Industry wine value* **--** Current production in New York around 2.0 T per acre on 300 acres. Estimated case production of 36,000 cases, with wholesale of $8 per bottle ($96/case) =. $3,456,000. I'd estimate that production has increased by 10-20% since 2013; so the increase in gross income to producers would range from $314,000-$576,000.

- *Webinar valuation* -- In a survey, we asked webinar participants estimate of the value of the information they received. How much money did estimate they would save, or how much extra income would result? The average reported by survey recipients for the 'value of the information' was $1000. For the 835 webinar attendees this amounts to a potential economic benefit of $835,000 or for the 84 New York participants it would amount to $84,000.

Overall potential economic impact:

Adding the above three estimates together, since the 2013 season, based on 300 acres of Northern Grapes cultivars:

Potential yield increase for improved training systems if fully adopted:		$720,000
Wine value (10% increase since 2013)		$314,000
Webinar valuation self-reported by 84 New York participants		**$ 84,000**
	Total:	**$1,118,000**

Lessons Learned

1. Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.

Funding from this project was crucial for maintaining *Northern Grapes Project* activities in 2013-2014, when the initial two years of funding for the National SCRI project ran out, and the Farm Bill renewing authorization for the NIFA Specialty Crops Research Initiative was delayed by Congress. Simply put, without funding from the Specialty Crops Block Grant program, we would have had to suspend field and winery trials associated with the project in New York and extension/outreach events like the *Northern Grapes Project* Webinar Series.

The *Northern Grapes Project* Webinar series was a primary way of getting project information out to educate new, inexperienced grape growers and winemakers in New York. Attendance in 2014 and 2015 totaled 1475, with topics spanning Northern Grape production, vinification, and marketing.

Extensive winter injury in the winter of 2013-2014 provided insights into the recovery of Marquette and Frontenac from winter injury in our training trials. We found that Frontenac trunks recovered well from winter injury, but secondary buds produced little fruit, while Marquette produced fruitful secondary buds and 50% of a crop in 2014.

Anna Katharine Mansfield's studies on Yeast Assimilable Nitrogen and chemical deacidification provided winemakers with information on winemaking techniques and concepts for dealing with unique characteristics of Northern Grape cultivars.

Miguel Gomez investigated Cost of Production and Establishment numbers for hybrids including Northern Grapes cultivars. A 2015 study is complete, and will be published soon.

2. Provide unexpected outcomes or results that were an effect of implementing this project.

The arctic vortex in 2014 produced winter low temperatures in the lower -30 ^{o}F range, providing growers throughout the upper Midwest and New York (especially Thousand Island region) with their first significant winter injury experience.

In 2015, a late spring frost led to >90% loss of primary shoots at our field sites. Frontenac produced a modest crop from secondary shoots that emerged after the frost, and it reached adequate

soluble solids by the October 9th harvest, but acids remained 4 to 5 grams/liter higher than those in the 'first crop.'

Early budburst and the risk of spring frost are the major production hazard to date with these varieties. Visits to 11 sites in the Thousand Island region in 2015 revealed that sites with good air drainage (hillside vineyards) suffered dramatically lower injury than those planted in low areas with poor air drainage.

3. If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem solving.

Field trials always have risk from variable weather events. That is why 3 to 5 seasons of data are needed to help make recommendations to growers about production practices.

Additional Information

Information from our trials and educational talks were delivered through a variety of publications and venues:

Meetings:

A. 17 July 2014. Mansfield, A.K., C. Gerling, T. Martinson and S. Kingsley-Richards.

Cultivar x Region: An NE1020 and Northern Grapes Project Tasting. Burlington, VT. 40 in attendance. (Photo below). Industry tasting of different wine styles and fruit from our NY and VT trials.

B. March 18-19. *Northern Grapes Symposium*. Hosted by the Eastern Winery Exhibition, Syracuse, NY. 480 in attendance.

- Martinson, T. E. (Cornell Univ.) and I. Dami (Ohio State Univ.). *Recovering from 2014 Winter Damage in New York and Ohio.* Eastern Winery Exhibition, Syracuse NY. March 18 2015.
- Dharmadhikari, M. (Iowa State Univ.) and A. Fredrickson (Cornell Univ.). *Managing, Adding, and Enhancing Tannins for Red Hybrid Fermentations*. Eastern Winery Exhibition, Syracuse NY. Eastern Winery Exhibition, Syracuse NY. March 18 2015.
- Martinson, T. (Cornell Univ.), G. Nonnecke (Iowa State Univ.), and P. Sabbatini (Michigan State Univ.). *Optimal Training Systems, Cropping Levels, and Canopy Management for Marquette, Frontenac, and La Crescent*. Eastern Winery Exhibition, Syracuse NY. March 18 2015.

- Dharmadhikari, M (Iowa State Univ.), and industry panelists Craig Hosbach (Tug Hill Vineyards, Lowville, NY), Kristina Randazzo Ives (Coyote Moon Vineyards, Clayton, NY) and Seth McFarland (Mac's Creek Winery and Vineyards in Lexington, NE). *Achieving Optimal Fruit Expression for White Hybrids*. Eastern Winery Exhibition, Syracuse NY. March 18 2015.
- Luby, J (Univ. of Minnesota), B. Gartner (Univ. of Minnesota) and A. K. Mansfield (Cornell Univ.). *Northern Grapes Project: Scope and Accomplishments.* Dr. Gartner covered branding studies and Dr. Mansfield discussed enology trials (including yeast selection, biological and chemical deacidification, and tannin addition) that were conducted as part of the *Northern Grapes Project.* Dr. Luby's talk provided an overall review of the *Northern Grapes Project*. Eastern Winery Exhibition, Syracuse NY. March 18 2015.
- Gomez M. (Cornell Univ.). *Consumer Expectations and Buying Patterns in the Tasting Room: Study Results.* Eastern Winery Exhibition, Syracuse NY. March 19 2015.
- McCole, D. (Michigan State Univ.). *Results of wine tourism studies in Michigan*. Eastern Winery Exhibition, Syracuse NY. March 19 2015.
- White, M. (Iowa State Univ.). *Launching Your Vineyard or Winery*. Eastern Winery Exhibition, Syracuse NY. March 17 2015.
- Martinson, T.(Cornell Univ.). *How to Achieve Economically Sustainable Vineyards with Quality Fruit.* Eastern Winery Exhibition, Syracuse NY. March 19 2015.

Northern Grapes Webinars:

Twelve webinars were presented, recorded and archived on the *Northern Grapes Project* website in fall 2013 through spring 2015.

- Groves, S. 12 November 2013. *The ABCs of the FSMA: The Food Safety Modernization Act and Wineries*.
- Haggerty, L. and J. Thull. 10 December 2013. *How grape ripening follows growing degree days and Managing vineyards for high quality*.
- McConnell, G. and D. McCole. 14 January 2014. Planning for future growth and investment in your winery and Best practices for winery collaboration.
- Mansfield, A.K. 11 February 2014. *Are you feeding your yeast? The importance of YAN in healthy fermentation.*
- Gartner, B. 20 March 2014. *Winery policies across the US and in the Northern States Region.*
- Martinson, T. and P. Sabbatini. 8 April 2014. *Impact of crop load and training systems on viticultural and enological performances of Marquette and Frontenac grown in Michigan and New York.*
- Lerch, S. and M. White. 20 November, 2014. *Trellis Design and Construction and Pruning Fundamentals Prior to Your First Cut*.
- Sacks, G. and J. Jastrzembski. 16 December 2014 *Stuck on You – Sulfur Spray Residues in the Vineyard and Winery*.
- Hart, M and T. Plocher. 13 January 2015. *Emerging Cold Hardy Wine Grape Cultivars*.

- Martinson, T. J. Tull, and B. Utter. 10 February 2015. *Comparing and Contrasting Vertical Shoot Positioning and Top Wire Cordon Training Systems*.
- Mansfield, A. K. 10 March 2015. *Building the Perfect Body: Tannin Strategies for Red Hybrid Wines*.

Northern Grapes Project Website:

Project information posted at: http://northerngrapesproject.org/ . Website continually updated through 2014 and 2015.

Research Reports:

Two page summaries of research results are posted on our website. NY project reports include:

- Wallis, A. *Willsboro Grape Variety Trial.* Yield and maturity measures from the 25 cold-hardy varieties planted at the Baker Research farm in Willsboro, NY.
- Martinson, T. and C. Particka. *Marquette Training Trial*. Cumulative results of the trial at Coyote Moon Vineyards in Clayton, NY.
- Martinson, T. and C. Particka. *Frontenac Training Trial.* Cumulative results of the trial at Coyote Moon Vineyards in Clayton, NY.
- Mansfield, A. K. and J. Luby. Optimizing Deacidification Methods for Cold Climate Cultivars.
- Mansfield, A. K. :Yeast Assimilable Nitrogen (YAN) Optimization for Fermentation of Cold Climate Cultivars.
- Gomez, M. and Y. Tang. *Establishing cost of production estimates for Hybrid Grapes in New York.*

Northern NY Grape Management Update:

- Seasonally timely updates were posted in 2014 and 2015 at the Northern NY Grape Management Update blog. In 2014, 36 posts were made and twelve were made in 2015. These were targeted at addressing weather and production issues, and went out to a mailing list of 198 growers from the Thousand Islands and Champlain regions.

Training trial pictures:

A major project goal was to continue our studies on the performance of Frontenac and Marquette under different trellising and training systems. Our field site was at Coyote Moon vineyards, Clayton NY, with cooperator Phil Randazzo. Top to bottom: Frontenac trained to High Cordon (top), Umbrella Kniffen (middle) or midwire cordon with Vertical Shoot Positioning (VSP) (bottom). High cordon performed better than VSP, yielding more grapes with much lower labor inputs.

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Project 11 (FINAL)
Expanding Market Competitiveness for Specialty Crop Producers at SUNY Colleges

Project Summary

A. Background

The *Expanding Market Competitiveness for Specialty Crop Producers at SUNY Colleges* or *Farm to SUNY* project was a demonstration project with four State University of New York campuses. Managed by American Farmland Trust's Farm to Institution New York State (FINYS) program, the project was designed to address barriers to increasing sales of New York State-grown fruits and vegetables to SUNY and other college campuses across the state.

Colleges are an emerging market for New York specialty crop producers as the state is home to more than 300 colleges and more than 1 million college students. Importantly, there is a growing voice among college students that are calling for their campuses to purchase more 'locally grown' foods, and a significant number of colleges have made sustainability commitments that include greater attention to the geographic origin of food they are purchasing.

While there is growing interest on college campuses to purchasing locally, the main barriers to operating successful farm to college programs for food service teams are 1) coordinating purchase and delivery of local products; 2) finding growers and other suppliers of local products; and 3) the seasonal availability of products. Common challenges for farmers looking to sell to colleges include 1) becoming an approved vendor for larger contract food service management companies such as Sodexo, Aramark and Chartwells, 2) meeting institutional volume and price expectations and 3) developing successful business relationships with university produce distributors.[1] This project aimed to address these barriers and ultimately help grow the college market opportunity for New York farmers.

The stated objectives of the project were to:

- Grow purchases of a discrete set of six fresh or minimally processed fruit and vegetable items by 25% year over year at each of the four pilot campuses, University at Albany, SUNY New Paltz, SUNY Oneonta, and SUNY Oswego.
- Educate at least 50 farmers and food service professionals at other colleges in New York about strategies for increasing purchasing of locally grown specialty crops. The goals specifically targeted the Empire State Fruit and Vegetable Expo and AFT's annual Harvesting Opportunities Conference.

The team also committed to:

- Increasing student knowledge of local fruits and vegetables through educational and promotional activities.
- Understanding the direct impact of the project on fruit and vegetable farmers

[1] Community Food Security Coalition Farm to College Survey.

Project partners included project lead, American Farmland Trust as well as the SUNY Office of Sustainability; four pilot campuses (University at Albany, SUNY New Paltz, SUNY Oneonta and SUNY Oswego); and consultants, Cornell Cooperative Extension Oneida County and Hudson Valley Agribusiness Development (HVADC).

The following criteria were used in selecting target campuses:

- Each campus needed to already be purchasing New York grown food and demonstrate a commitment to expanding such efforts.
- The mix of campuses needed to be made up of at least one self-operated college/university and represent at least two different food service management companies, such as Chartwells/Compass Group and Sodexo USA, the market leaders in campus dining in New York State.
- Each campus needed to be in a different region of the state.
- The Food Service Director, Sustainability Director and the Executive Director of Auxiliary Services needed to support participation in the project.

About the Pilot Campuses

- University at Albany was the largest of the participating schools with over 17,300 students, plus faculty, serving between 20,000-25,000 meals per day. The campus food budget is $19.9M. Albany has a very aggressive goal to procure 50% of foods by the end of 2015 locally (250 miles). One of Albany's major successes has been with protein. The school is purchasing all pork products and beef products locally through Purdy and Sons. The campus transitioned Dining Services management from Chartwells to Sodexo at the start of the Farm to SUNY project. The Sodexo contract includes local procurement targets.
- SUNY New Paltz enrollment includes 6,570 undergraduates and 1,088 graduate students. About 3,500-3,700 meals are served per day. The campus food budget is $8.4M. New Paltz is a 'Real Food Challenge' school meaning that they have committed to purchasing from small, nearby, community based food producers with ecologically sound practices. Sodexo manages New Paltz's Dining Services and as an organization has also made a commitment to participate in the Real Food Challenge.
- SUNY Oswego has 8,000 students with 4,400 living on-campus. The campus food budget is $12.7M. Oswego's Dining Services are "self-operated" which means they are managed by SUNY Oswego Auxiliary Services staff, not contracted out to a food service management company. At the start of the project, the campus was already purchasing fresh produce from local distributor, C's Farm, and having success procuring local vegetables.
- SUNY Oneonta has 3,400 residents. Sodexo manages Oneonta's Dining Services. The campus food budget is $6.8M. The distributor, Mento Produce, was already buying from many Central New York farms and Eden Valley Growers at the start of the project. The campus was in the process of redesigning its meal plan program to encourage student adoption of more "all you care to eat" plans in the main dining halls. Much of the local produce focus at the start of the project was geared to the smaller retail dining venues where higher price-point items are marketed a la carte.

B. Motivation for Launching Farm to SUNY

The 29 state-university operated campuses spend well over $150M per year on food.[2] The SUNY network of 64 campuses feeds roughly 550,000 students and faculty daily.[3] Prior local food successes within the SUNY network demonstrated that a significant market opportunity exists for farmers. The project built upon efforts begun by the SUNY Office of Sustainability's 'SUNY Commits to New York State Agriculture' program that focused on the development of a SUNY pizza sauce in partnership with processors Winter Sun Farms, in Kingston, NY and farmer-processor, Tasselberry Farms, in Westmoreland, NY (the latter was developed for distributor Purdy and Sons).

The timing of the project was motivated by strong interest from SUNY Office of Sustainability in collaborating to grow the SUNY Commits effort. Campus-driven local food initiatives at institutions such as University at Albany, Cornell University, and SUNY New Paltz were also encouraging. For example, the University at Albany dining halls served roughly 10,000 pounds of frozen vegetables grown by New York farmers in 2012-13, with the school spending approximately $60,000 per semester on vegetables grown in New York.

Lastly, New York State Governor Andrew Cuomo has prioritized greater procurement of food grown in New York by state agencies and signed the state's Food Metrics Law in 2013 to require state agencies to track and report the geographic origin of food purchased with state dollars. This greater awareness of local food purchasing across state government further added to the motivation for this fruit and vegetable project with a network of state-operated SUNY campuses.

Project Approach

The approach to increasing local purchases of at least 5 fruit and/or vegetable products on each campus was to utilize a combination of "value chain facilitation" (connecting farm sources to distributors and processors) and student-led marketing efforts to increase student awareness and demand through events, educational and media activities.

The approach was highly collaborative. More than 40 individuals were actively involved in the operations of the Farm to SUNY pilot including:

AFT/FINYS
David Haight
Glenda Neff
Laurie Ten Eyck
Tammey Holtby
Olivia Fuller
Christina Grace (project lead)

SUNY Office of Sustainability
Deborah Howard
Adam Costello

University at Albany
Mary Ellen Mallia
Mary Alexis Leciejewski
Tim MacTurk
Michelle Bowen
Karen Kettlewell
Stephen Pearse
Stephanie DiBacco (no longer at UAlbany)
Radha Urribarri

[2] State University of New York Auxiliary Services Corporations 2013-14 Campus Operations Report, May 18, 2015, page 10.
[3]

SUNY New Paltz
Lisa Mitten
Steve Deutsch
Diane Jackson (no longer at New Paltz)
Matthew Hill
James McKenna (no longer at New Paltz)
Michael Hoysradt
Jennifer Lischer
Don Diamond
Emily Ferencik

SUNY Oneonta
Hannah Morgan
James (Jimmy) Hamm III
Diane Williams Davidson
Nicole Brown
Rex Smith
Kathleen Schmid

SUNY Oswego
Jamie Adams
Steve McAfee
Craig Traub
Ruth Stevens
Rob Clark

Distributors
Kevin Terr, Red Barn
Anthony Carioto, Carioto Produce and Seafood
C's Farm, Dave Johnson
Frank Mento and Fred Mento, Mento Produce
Sherri Dunlop, FreshPoint
Dan Purdy, Purdy and Sons

Campus Teams

Each campus had a Farm to SUNY team including the food service director, sustainability director coordinator, student intern(s), FINYS team lead, and supply expert. Teams also had active participation from chefs, marketing staff, and Auxiliary Services executive leadership.

Marketing Team
In addition to the individual campus teams, the project developed a marketing team made up of participating sustainability directors, marketing professionals, student interns and AFT team members Christina Grace and Glenda Neff. Led by Mary Ellen Mallia, the Director of Sustainability at University at Albany, the Marketing Team ensured coordination across the four campuses on key Farm to SUNY campaign initiatives.

Supply Team

Led by Christina Grace, the supply team included Glenda Neff, AFT; Mary Ann Johnson, HVADC; and Marty Broccoli of CCE Oneida. This team was responsible for providing technical assistance to Dining Services working directly with distributors and producers. Its role was also to work closely with distributors, produce processors and farmers to ensure communications through the value chain so target products were procured and local purchasing data was provided to each campus.

Table 1: Farm to SUNY Work Plan

Task/Project Activity	***Partners***	***Completion Date***
Project Management - Oversight and coordination of project delivery.	AFT/FINYS	Ongoing
Team Communications - Regular conference calls among project team members. • Campus teams had monthly conference calls. • The full project team participated in monthly conference calls during year 1 and bi-monthly calls during year 2. • The Supply and Marketing teams participated in monthly calls during year 1 and bi-monthly calls year 2 or more frequently as needed.	Full team (AFT/FINYS-led)	Ongoing
Supply Assessment – Collect data on grower, processor and distributor production capacity. • Develop survey. • Conduct phone and electronic surveys (with up to ten growers and processors). • Conduct 4-6 meetings with food processors. • Identify 5-6 target products including at least 2 minimally processed specialty crop items suitable for distribution to each campus.	AFT/FINYS (Lead), CCE Oneida, HVADC	Q1 2014

College Demand Assessment – Gather baseline data on purchasing by college dining services and needs for a specified list of available products. Meetings and phone calls with food service and other college staff.	AFT/FINYS (Lead), Food Service Directors, Distributors	Q4 2013
Matchmaking - Connect food service staff and distributors with local vegetable processors and vegetable groups, convene site teams and conduct product tests.	AFT/FINYS (Lead), CCE Oneida, HVADC	Ongoing from Q1 2014 through Q3 2015
Consumer Outreach/Campus Campaigns - Design and implement local produce promotional campaigns at the four campuses using new and existing materials such as Pride of New York tools: • Harvest of the Month (Primarily fruits and vegetables with the exception of the addition of maple syrup, a specialty crop, at Oneonta and Oswego in April) • National Food Day/Campus Crunch (promoted apples) • National Kale Day • Day of the Mushroom (at 2 of the 4 campuses) Video – The original work plan included in multi-campus video project. Due to budget and logistics challenges, the video was replaced with a profile on Farm to SUNY, *Scaling Up Farm to SUNY: Nothing but the Best, Local and Fresh*	UAlbany(Lead), Sustainability Directors, AFT/FINYS, Student Interns, Food Service Marketing Staff	Ongoing from Q2 2014-Q3 2015
College Convenings 1. Pilot Team Convening: Hold convenings of pilot campus teams to share work to date, challenges and best practices: - Year 1 at University at Albany - Year 2 at SUNY Oneonta 2. SUNY Annual Sustainability Conference(s) - Share project overview year 1 and results year 2 with SUNY sustainability professionals. Present 'best practices'. 3. SUNY Auxiliary Services Conference - Year 1 and Year 2. Share project overview and best practices with campus directors of auxiliary services, dining services directors, chefs, marketing and other food service staff.	AFT/FINYS (Lead) All partners Albany Sustainability (Lead) All Sustainability Directors, Office of Sustainability AFT/FINYS (Lead) Oswego Director of Dining Services	 12/4/2013 2/13/2015 9/24/14 4/16/14 1/7-8/15

Measurement/Evaluation – Design evaluation tools to track sales to target colleges. 1. Track procurement changes. Summarize results for farmers and SUNY food service managers and Sustainability Coordinators. 2. Create a student fall and spring survey to measure changes in student perceptions and awareness of local fruits and vegetables, specifically the Harvest of the Month promotions, over the course of the project period. 3. Create and administer farmer survey to help evaluate project impact.	AFT/FINYS (LEAD)	Ongoing through Q3 2015 Fall 2014 Survey Completed 12/14. Spring 2015 Completed 8/15. Completed 9/30/15.
Train 50 farmers about project results and opportunities. • Present to growers at the 2015 Empire Fruit and Vegetable Expo. • Developed a public-facing educational and promotional piece called: "Scaling Up Farm to SUNY: Nothing but the Best, Local and Fresh" (added to original work plan)	AFT/FINYS	1/22/15 8/6/15
External Communications Promoted the initiative to other farm to college stakeholders including farmers, students, college staff and faculty, government agencies through media and events. This included the launch of a Farm to SUNY page on the FINYS.org website: http://finys.org/our-projects/farm-suny. (Added to original work plan)	AFT/FINYS	PR happened throughout the project. The webpage launched in September 2015.

The project activities focused solely on increasing sales of specialty crops, primarily fruits and vegetables. The specialty crops promoted through the project - primarily Harvest of the Month products - were agreed upon by the group (see report page 19). Upon request, we did add maple syrup as it is a New York Specialty Crop and there was strong interest on behalf of two of the four campuses.

American Farmland Trust participated very closely with each campus in the planning of events and development of materials. A substantial portion of marketing materials funding went to promote two events - Campus Crunch and Kale Day - to promote purchasing of apples and kale.

A. Supply Assessment

In March 2014, the Supply Team released a survey targeting specialty crop farmers currently serving wholesale markets. The survey was meant to 1) Identify farmers interested in selling into the college marketplace through the existing network of distributors; 2) Clarify farmers' capacity

to meet institutional requirements; and 3) Document availability of local produce items. The survey was completed in June 2014.

Twenty-five (25) producers expressed interest, while 18 completed the full survey. Respondents provided detailed information about product availability, shipping and distribution methods, and food safety planning/GAP certification. The key findings were that 17 out of 18 respondent farmers use distributors to deliver wholesale products, which is critical to the project. Some were already working with distributors supplying the participating campuses (Mento Produce (5), C's Farms (3), and Red Barn (2)). Eighteen (18) farmer respondents had existing food safety plans and 12 were GAP certified, also critical to serving institutional markets.

Table 2: Top Produce Items by Weight from Farmer Survey Findings

Produce Item	Total Pounds
Sweet Corn	58,165,582
Cabbage	22,966,450
Yellow Onions	13,195,000
Apples	10,556,112
Bell Peppers	4,807,928
Leafy Greens	4,597,840
Other Potatoes	3,728,000
Summer Squash	3,265,757
Green Beans	1,959,372
Romaine	1,620,000
Eggplant	1,085,548
Yukon Potatoes	1,000,000
Winter Squash	934,000

B. College Demand Assessment

Data collection on produce purchases for demand analysis and ongoing tracking was the most challenging aspect of the project. Each campus team was charged with collecting fall purchasing data from August 2013 through December 2013. When available, data was collected for the spring semester of 2014. The quality and breadth of data provided depended greatly on the participation of each campus's distributors. The team determined that the demand analysis should include purchases of all produce items, fresh and minimally processed, that are available from New York farmers.

Data included items currently being purchased from sources outside New York and those already sourced locally. AFT staff provided each campus with a list of produce items that are grown in New York and shared the New York State Department of Agriculture & Markets' *Pride of New York Harvest Chart*. We developed a template for demand data collection with the following data requirements: *produce item, description, quantity, unit, total cost, unit cost, distributor/supplier, processor, farm source name, and farm location*.

The challenge for distributors was correlating farm source information with historical purchases. In general this was a manual process for distributors to compile the information – to go back and

identify the produce farm or broker sources from a particular month. Only one distributor had a database in place that allowed them to run an automated purchasing report with farm suppliers included.

Each campus's distributor was asked to provide the purchasing data for the 2013-14 school year. Distributors included C's Farm Market, Oswego; Carioto Produce & Seafood, Green Island; Mento Produce, Syracuse; Red Barn, Highland; Sysco, Albany; and FreshPoint, Hartford, CT. Purdy and Sons provided data on frozen New York vegetable purchases for University at Albany.

We received local purchasing data from the primary fresh produce vendors: C's Farm Market, Carioto Produce, Mento Produce, Red Barn and Fresh Point. We received data on frozen produce purchases from Purdy & Sons to University at Albany and some fresh cut and frozen purchase data from Sysco to SUNY Oneonta. We also met with and had ongoing communications with Sysco in Albany, but the distributor was not able to provide farm source data for frozen and fresh-cut products purchased by University at Albany and SUNY Oneonta. <u>This highlighted that even for the larger distributors, correlating farm source data with products is a big challenge with current business processes and ordering systems.</u>

Once the supply team received the historical purchasing data from each campus or distributor, it worked to validate the information. Since distributors sourced much of their product through farmer-brokers, the team needed to follow up with these brokers to determine if the farmer-broker grew the fruits or vegetables, sourced them from another New York farmer or brought them in from outside of the state. The same validation was required with minimally processed items. The team followed up with processors to get farm source information. Winter Sun Farms was the only non-farm supplier that included farm source information on case labels, invoices and packing slips. Based in Kingston, NY, Winter Sun processes frozen vegetables and the SUNY-branded pizza and marinara sauces.

The other participating processors where Capital City Produce, Menands and frozen vegetable processor Bonduelle in Brockport. Capital City Produce is small scale and processes primarily by hand and the company was able to provide farm source data. Bonduelle was able to share that it purchases from Farm Fresh First.

Note that the project did not require each campus to provide a comprehensive list of all fresh, frozen and minimally-processed produce items. Albany's data included only products purchased through Carioto Produce and Purdy and Sons. Oneonta provided data from their internal system, so the first wave of information lacked farm source data, but included vegetable and fruit items available in New York. New Paltz limited the initial data capture to local purchases through Red Barn, with only fresh produce and Winter Sun Farms' minimally-processed items. Later in the process we received data from FreshPoint. Oswego limited data collection to C's Farm and chose not to include frozen products as part of the project.

The information provided was used to identify "hot products" (see Table 3) that at the time were purchased from outside of New York State, but could be purchased in state, most likely during the prime harvest season. The process of collecting the demand data also informed our plans for tracking purchases going forward.

Demand Study Findings:

- Campuses were purchasing little to no local fresh cut produce.
- All of the schools were already procuring some fresh, unprocessed produce locally.
- Two of the four schools were already purchasing local frozen corn, peas, green beans, carrots and mixed vegetables processed by Winter Sun Farms, Kingston or Bondeulle Group, Brockport (packaged by Holli-Pac, Holly and distributed by Purdy & Sons, Sherburne).
- Three of the four campuses purchased marinara and pizza sauce developed specifically for SUNY through the SUNY Commits initiative. The sauces were made from tomatoes grown in New York that were processed by Winter Sun Farms and Tassleberry Farm, Westmoreland (for Purdy & Sons).
- The food service teams were all constrained by existing distribution contracts. Any farmer or food processing company identified by the Supply Team had to be able to partner with the contracted produce distributors.

Table 3: "Hot" Products Derived from Supply and Demand Analysis

Fresh Unprocessed	Original Strategy based on the Supply Analysis
Apples (Widely available)	Work through distributors existing suppliers.
Potatoes (Widely available)	Work through distributors existing suppliers.
Onions (Widely available)	Work through distributors existing suppliers.
Romaine Heads (Widely available)	Partner with North Country Growers Cooperative. Assess opportunity for cut, washed romaine through Capital City Produce, a small processor at Menands Market, to explore limited fresh cut.
Watermelon	Identify farm sources through existing farm suppliers.
Mesclun Salad Mixed	Identify farm sources through existing suppliers.
Fresh Cut	
Potatoes - 25# Peeled	Start with Capital City Produce, but due to minimal supply and cost, pilot a project with Baldor Specialty Foods in Bronx, NY to scale up processing. Baldor was already processing peeled potatoes from other regions. The plan was to test New York potato varieties. Baldor is a large produce distributor, but was to act as a processor working with existing distributors.
Potatoes - diced	Same strategy as above for peeled potatoes.
Yellow Onions - sliced	Same strategy as above for peeled potatoes.
Yellow Onions - diced	Same strategy as above for peeled potatoes.
Winter Squash - cubed	Available through Baldor Specialty Foods, Capital City Produce, Wertman Farm and Martins Farms.
Snipped Green Beans	Had early discussions with Fingers Lakes Fresh who was already being encouraged to process snipped green beans by Mento Produce. Note that due to a shift in strategy for Finger Lakes Fresh, green beans were dropped from potential new products.

Kale - chopped	Consider opportunities through Capital City Produce using product from North Country Growers Cooperative and others.
Broccoli Florets	Supply of broccoli is limited, but the product is in high demand. The Supply Team connected with Cornell University's Eastern Broccoli Project in the hopes of identifying supply. The timing was off and the Cornell team was looking for a small set of very large buyers for expected volumes.
Frozen	
Corn on the Cob	The plan was to move develop a new product with Winter Sun Farms in Kingston, NY.
Fajita Mix	Winter Sun Farms in Kingston offered a product that campuses were interested in, but not currently buying. The plan was to promote the product to participating campuses.
Broccoli Florets	Limited quantity is available through Winter Sun Farms. Working to identifying other sources. The plan was to promote this product to campuses. It was not available from other frozen produce processors in NYS.
Roasted Root Vegetable Mix	This product was developed and tested by Winter Sun Farms for the Poughkeepsie Farm to School project and was a hit with K-12 students. It is not currently in production, but the SUNY campuses were interested. The goal was to generate enough demand to interest the processor in adding the product to its line permanently.

While the Farm to SUNY Supply Team provided technical assistance to campus Dining Services, the food service directors were ultimately responsible for determining which products their campuses would prioritize.

Initially, we sought to identify two minimally processed products that all four campuses could purchase together. The goal was to pool demand to create incentives for food processors to develop new products, if necessary. Since products and suppliers were limited to each SUNY campus' current supply chain, it was not possible to get agreement on a shared list of target products across the four campuses.

In the end, each campus team worked on its own list of target products, although there was significant overlap in the purchasing successes. Across the board, campuses worked on more than six items in order to guarantee they would meet the project's objective of 25% growth per product and because the participants' commitment to increasing local purchasing transcended the Farm to SUNY project.

C. Sourcing, Matchmaking, and Tracking Progress

Supply team members from AFT, CCE Oneida and HVADC, met with distributors and toured distribution facilities to cultivate strong relationships with distributors as the distributors were

responsible for 1) providing monthly 'local purchasing' reports, 2) working with new local suppliers and 3) capturing opportunities to move more local product from existing suppliers.

SUNY Albany's supplier for fresh and fresh cut produce is Carioto Produce. UAlbany purchases frozen produce from Purdy and Sons and Sysco Albany.

SUNY Oswego sources fresh produce and all local produce from C's Farm based in Oswego. The campus purchases fresh cut and frozen produce from Sysco Syracuse.

SUNY Oneonta purchases all fresh produce and some fresh cut from Mento Produce. The team relies on Sysco Albany for frozen and non-local fresh cut produce.

SUNY New Paltz was purchasing a great percentage of local and some non-local produce from Red Barn Produce based in New Paltz. Over the course of the project the campus began to work with FreshPoint based in Connecticut. They have now moved their produce purchases to Baldor Produce, Bronx, but continue to purchase some local specialty items from Red Barn.

The team met with:

- Carioto Produce – Visited by Christina Grace and Mary Ann Johnson
- C's Farm (produce) – Visited by Glenda Neff and Mary Broccoli
- Mento Produce – Visited by Glenda Neff and Marty Broccoli
- Red Barn Produce – Visited by Christina Grace and Mary Ann Johnson
- Sysco Albany – Visited by Christina Grace, Marty Broccoli and Mary Ann Johnson (UAlbany's Food Service Director, Tim MacTurk, also participated.)

The supply team worked with distributors, processors and growers to identify and procure target and harvest of the month products. Campus purchasing data and product-specific outcomes are described in the Local Produce Procurement Outcomes Section on page 25.

The supply team worked primarily with the four dedicated produce distributors to identify opportunities. We identified which products were "purchase ready" and where the supply team needed to focus its energies. Through their distributors, campuses were able to readily procure the following "target products" from local farmers:

- A diverse variety of local apples (Ida Red, NY Style, Honey Crisp, Macintosh, Jona Gold, Rome, Gala, Cortland, Empire, Macoun, Fuji, Gala, and Golden Delicious, Red Delicious)
- Red and white B size, "regular" red, chef, salt (C size)
- Red and white onions
- Winter squash (cut/cubed)
- Sliced and diced onions. Albany and Oneonta were able to meet a portion of demand through Capital City Produce. Torrey farms supplied the onions.
- Albany was also able to procure cut potatoes from Capital City Produce.

Below are further details describing efforts to expand purchasing of targeted specialty crops:

Table 4: Targeted Product Efforts

Fresh	
Romaine Heads	The team connected North Country Grown Cooperative to University at Albany, Carioto Produce and Mento Produce. Mary Ann Johnson also organized a meeting with Capital City Produce to explore chopped romaine. Unfortunately in March 2015, North Country Grown Cooperative cut back its wholesale business, citing the loss of key college accounts as instrumental in the closure.
Watermelon	Through Upstate Growers and Packers annual event, Glenda Neff was able to connect Al Lansing, Lansing Farm, to the project. Al grew watermelon for Carioto Produce to deliver to University at Albany. Watermelon was also available through Tassone, Emmi and DeConinck Farms.
Fresh Cut	
Potatoes - 25# Peeled	Supply was available through Capital City Produce. Capital City has limited capacity to scale up as processing is primarily manual. We discussed considering opportunities to increase processing capacity and HVADC shared information about REDC/CFA funding with Capital City. The team also reached out to Baldor Specialty Foods to discuss processing local onions. Baldor is still exploring the opportunity to process New York varieties.
Potatoes - diced	Supply was available through Capital City Produce. We discussed considering opportunities to increase processing capacity and HVADC shared information about REDC/CFA funding with Capital City. The team also reached out to Baldor Specialty Foods to discuss processing local onions. Baldor is still exploring the opportunity to process New York varieties.
Yellow Onions – sliced and diced	Albany and Oneonta were able to source sliced and diced onions processed by Capital City Produce, through their distributors. While Baldor was open to develop a local product, the campuses did not have a need for additional supply.
Winter Squash - Cubed	Working with distributors the team was able to identify multiple sources for cut winter squash which became a target product for three of the four campuses. Squash was supplied by Martins Farm, Wertman Farm and Torrey Farms (processed by Capital City Produce). Baldor also offered cut local winter squash from Hepworth Farms, both conventional and organic, but the distributors were able to source squash through existing suppliers.
Snipped Green Beans	Marty Broccoli, Glenda Neff and Mento Produce met with Fingers Lakes Fresh. Early in the project there was interest, but due to a refocus in Finger Lakes Fresh's product strategy, the project was put on hold.

Broccoli Florets	Broccoli is in limited supply in New York. The Supply Team reached out to Thomas Bjorkman at Cornell University who is currently leading the Eastern Broccoli Project, working with New York farmers and academic peers to increase production of broccoli throughout the region. The project has been testing varieties of broccoli to be sold as full broccoli heads and potentially for processing into fresh-cut florets. Unfortunately, the Farm to SUNY pilot campuses represented too small a market to be an outlet for the broccoli pilot. Instead, the team was seeking very high volume purchasers such to anchor the project. We see potential for the next state of the broccoli project to connect to Farm to SUNY distributors.
Frozen	
Corn on the Cob	The supply team worked with Winter Sun Farms to test a frozen corn on the cob product. Albany, Oneonta and New Paltz tested and approved the product. Sodexo's regional director for Customer Support, Client Procurement Services, John Stewart, also expressed interest in the product for a broader market. But, Winter Sun did not move forward on production of the product due to the current cost of the pre-processing the corn (shucking and cutting the ears).

D. Consumer Outreach/Campus Campaigns

By April 2014, the Marketing team had put forward core components of a Farm to SUNY campaign and secured commitment from the Food Service Directors and SUNY Sustainability to move ahead. The marketing and outreach plan included hiring student interns, working with SUNY students at each campus to design social media messages and promotional materials for events, launch student marketing plans, and develop a video to promote Farm to SUNY students, farmers, and other key stakeholders.

The Marketing team collaborated closely on joint initiatives including:

Logos and Taglines:

- Multi-campus student campaign to develop a Farm to SUNY marketing tagline. The winning was, "*Nothing but the Best, Local and Fresh*". (Appendix D).
- Development of a shared logo

Figure 1: Farm to SUNY Logo

Harvest of the Month:

The marketing team developed a Harvest of the Month campaign strategy to highlight a special New York State vegetable or fruit each month of the academic calendar, August through May.

Each month a vegetable or fruit was included in a variety of menu items and widely promoted through signage, samplings and special events. The campaign featured:

- August: Watermelon
- September: Corn
- October: Apples
- November: Winter Squash
- December: Winter Squash (due to short month)
- January: Pizza sauce
- February: Onions
- March: Potatoes and other roasted root vegetables
- April: Maple Syrup (Oneonta and Oswego) and Mushrooms (Albany and New Paltz)
- May: Planned for Spring Greens, but due to low availability and the short month, schools continued to promote the April items into May.

See the appendices for sample Harvest of the Month promotional materials and sample recipes that showcase some of the Harvest of the Month vegetables and fruits.

National Kale Day:
On October 7, 2014, each school served New York kale in a variety of recipes. Lisa Mitten, Sustainability Coordinator at SUNY New Paltz championed bringing National Kale Day into the Farm to SUNY project. There was skepticism from the food service directors, but the campaign was a success and kale is now being served more regularly at all four campuses. See Appendix X for example recipes for Kale Day.

Figure 2: National Kale Day, University at Albany

National Food Day / Campus Crunch:
On October 24th, each campus held National Food Day events. Food Day was anchored by the Campus Crunch. At all four schools, students bit into local apples at the same time in celebration of Food Day and as an extension of the Big Apple Crunch run by GrowNYC in New York City. The University at Albany team coordinated a website and outreach to other schools resulting in 18 schools in New York State joining in the campus crunch. Over 4,000 people across participating campuses crunched into an apple. The New York Apple Association provided materials.

Figure 3: Campus Crunch at SUNY New Paltz

Other events included Soup Month and Local Soup Night at SUNY New Paltz and Day of the Mushroom at New Paltz and Albany.

Each campus also had many of its own Food Day activities and the teams coordinated:

- Website materials
- Shared listserv and Google Drive
- Posters
- Looping Display Monitor Marketing in Dining Halls
- Napkin Holders
- Tabling
- Social media
- Speakers

Figure 4: Student Speaker Radha Urribarri at UAlbany with Apple Farmer, Peter Ten Eyck, Indian Ladder Farms on National Food Day.

The Marketing Team was responsible for spreading the word about Farm to SUNY in collaboration with AFT through public presentations, press releases and a video project. The goal of communications efforts was to engage additional campuses and farm to college stakeholder in the effort.

- *Presentations:*
  The team delivered presentations at key SUNY, college sustainability and regional food events to extend the work to share best practices and support farm to college efforts throughout the state and region. The project components and results at various stages of the initiative have been shared at:
  - 2014 SUNY Auxiliary Services Conference, April 16, 2014 (24 session participants)
  - Hudson Valley Farm to Institution Summit, October 16, 2014 (35 presentation participants, 140 conference participants. The event was held at SUNY New Paltz where local produce was served and the Farm to SUNY project was promoted to the entire group)
  - Northeast Sustainable Agriculture Working Group Conference (NESAWG), November 11, 2014 (48 presentation participants)
  - 2015 SUNY Auxiliary Services Conference, January 7-9, 2015 (45 session participants)
  - Empire State Vegetable and Fruit Growers Expo, January 20-22, 2015/The Becker Forum. The target audience was fruit and vegetable growers and only 10 produce farmers were present although there were more participants in the session.
  - Farm to Institution Northeast Summit, April 7-9, 2015. Farm to SUNY was promoted on the student plenary panel for the Farm to College day to over 250 people and there were two Farm to SUNY presentations, 1) Farm to SUNY Scaling Up with 44 participants and 2) Strengthening Local Food Links with 32 participants.
  - Annual Association for the Advancement of Sustainability in Higher Education (AASHE) Annual Conference, October 26-29, 2014 (36 session participants)

- *"Scaling Up Farm to SUNY" Marketing Piece*
  The project launched with plans for a multi-campus student video project to document Farm to SUNY. Jaime Adams, faculty member and Sustainability Coordinator at SUNY Oswego, took

a leadership role in developing plans for the video project. The initial plan was to identify students with filming experience to take footage of Farm to SUNY events. However, the Sustainability Directors were unable to identify experienced students at each campus to lead the project. As a result, it was agreed that a high quality printed piece would meet the goals for creating the video.

AFT staff with support from HVADC and a broad set of project participants, developed *Scaling Up Farm to SUNY: Nothing but the Best, Local and Fresh.* The document is a valuable background piece on the project that describes the project process, early successes and challenges for further growth of specialty crop sales to colleges.

- *Local Fruit and Vegetable Recipes:*
  SUNY Dining Services shared Harvest of the Month and other local produce recipes which were formatted and added to a Farm to SUNY Google Drive folder.

E. Student Perception Surveys (Fall 2014 and Spring 2015)

The purpose of the student spring and fall surveys was to measure student awareness and perceptions of efforts on campus to purchase local specialty crops. The Marketing Team collaborated to develop the survey tool and student interns administered the survey and compiled results.

Students were surveyed at Albany (210), Oneonta (25) and Oswego (100) in Fall 2015, and then again in Spring 2015 to gauge whether the marketing efforts have increased interest in and awareness of local fruits and vegetables in the dining halls.

Survey findings were encouraging for future Farm to SUNY efforts. According to aggregated spring survey results from the three campuses, 70% of students responded that they cared about where their food was grown and 60% cared about their respective school's local food procurement plan. At Oneonta, over half of the students responded that they would eat more frequently in the dining hall if it served local food. Albany and Oneonta's spring surveys also included a tradeoff question, with 34% of Albany students, and 56% of students at Oneonta, stating that would be willing to pay more for food that is locally grown. These numbers reflect a student body that is supportive of local food and care about their dining halls' efforts to buy local fruits, vegetables and other specialty crops --even potentially at a higher cost.

Figure 5: Student responses when asked “Does it matter to you where your food is grown?” (Spring 2015)

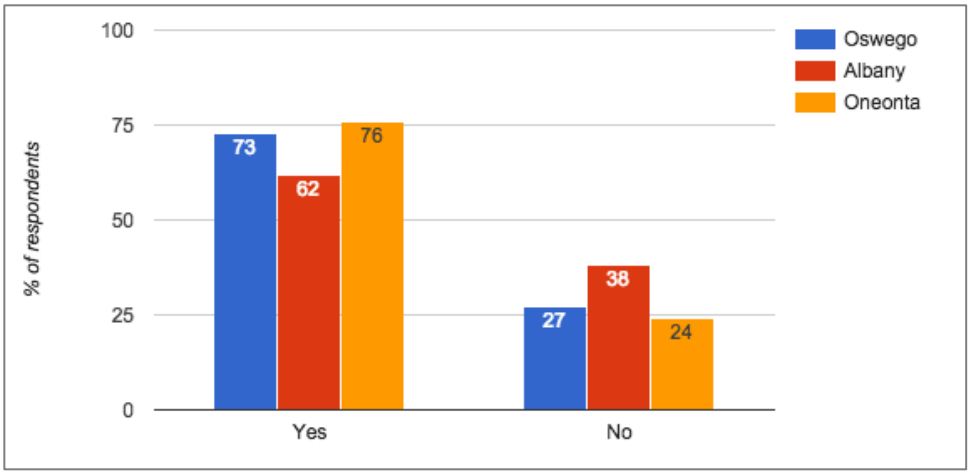


Figure 6: Student responses when asked “Does your school’s local food procurement plan matter to you?” (Spring 2015)

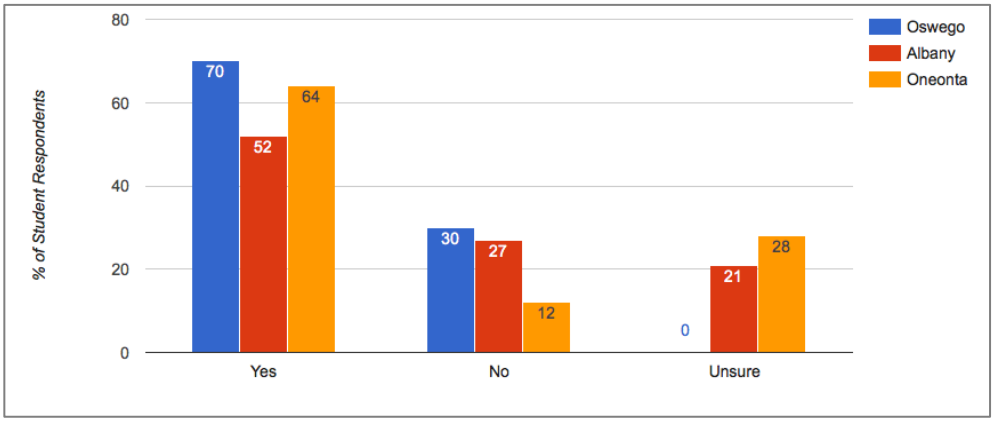


Figure 7: Student responses when asked “Would you eat more frequently in the dining hall if it served local food?” (Spring 2015)

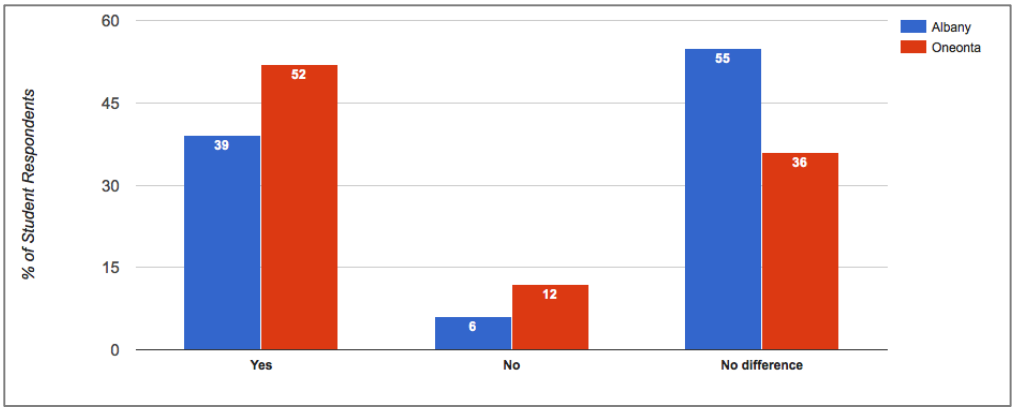
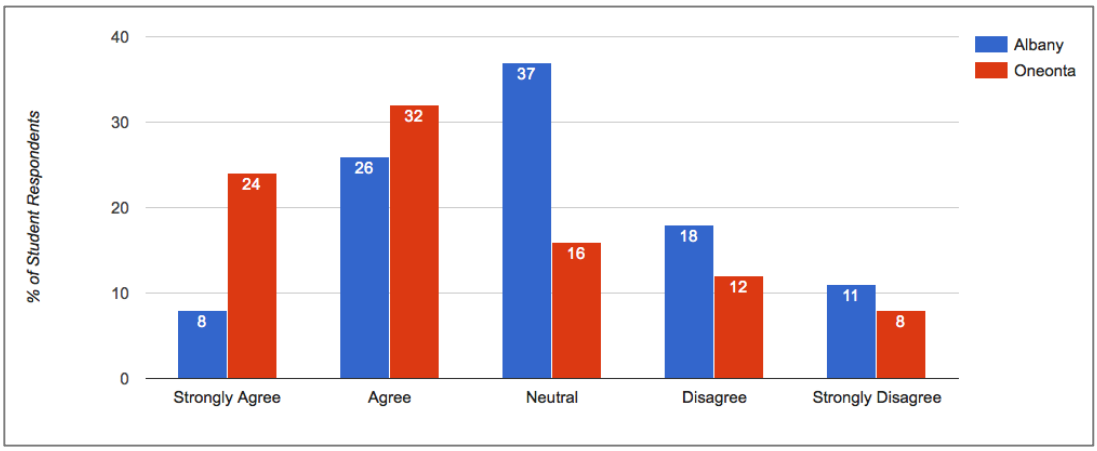


Figure 8: Student responses at Albany and Oneonta when given the statement “I would be willing to pay more for food that is locally grown.” (Spring 2015)

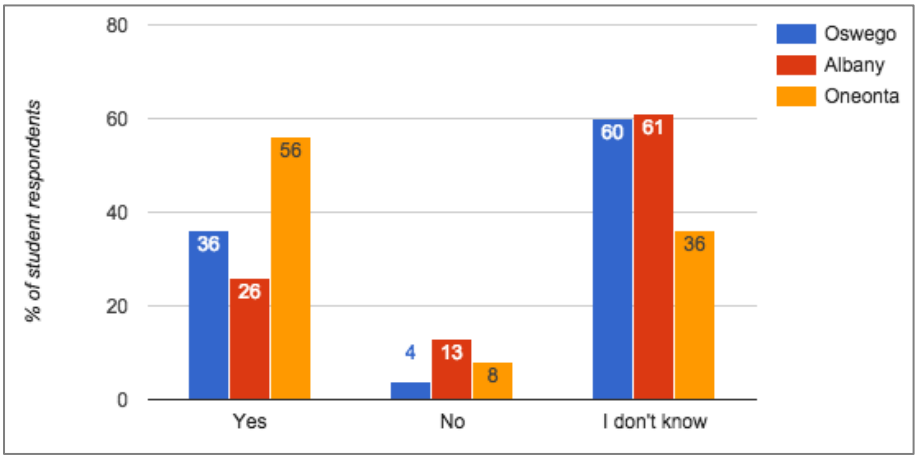


However, the surveys also suggest that there remains a gap in the education and marketing of local specialty crops being served in SUNY dining halls. While students are open-minded and want to support local food and new products, more than half surveyed were unaware of the efforts taking place in their dining halls, and unclear on the benefits of eating locally.

More specifically, according to the Spring 2015 surveys, 70% of students care about where their food is grown and 60% support their school’s local food procurement plan, yet only 39% think that their school serves local food, with 52% stating “I don’t know” (Figure 9). At Albany, the majority

of students responded “Neutral” when asked if they make an effort to know where their food comes from and how it is grown and produced.

Figure 9: Student responses when asked “Do the dining halls serve local food?” (Spring 2015)



There was little to no change between Albany and Oneonta’s fall and spring survey data. At University at Albany, there was only a 3% increase in the number of students aware that their dining hall served local food (23% to 26%), and only a 4% increase in students who cared about where their food comes from. At Oneonta, student awareness of whether local food was served in their dining hall remained at around 55% across the two surveys, and there was even a decrease of 20% from fall to spring in the number of students who said they would eat more frequently in the dining hall if it served local food.

It is important to note that while a comparison of fall to spring data suggested little to no change in student awareness and perceptions of local food initiatives, these findings do not likely reflect the project’s full impact. The fall surveys were not administered until October and November due to delays in hiring interns and findings were not compiled until December. With two of the largest Farm to SUNY events taking place in October—Campus Crunch and National Kale Day—students had already been exposed to these programs before the fall survey was conducted – potentially impacting the students perceptions that existed before the Farm to SUNY project began.

Student survey results also suggest that the awareness of local fruits and vegetables on campus is not as high as anticipated. This speaks to a need to make promotions more visible, but also may point to the need for more time to change student behavior and perceptions. Also, Farm to SUNY outreach remained relatively general because specific information about local farmers was difficult to obtain at the time products were served. This made it challenging to bring farmers into marketing efforts and to draw on personal connections as is common in other types of food marketing.

F. Farmer Survey

The purpose of the Farmer Survey was to validate farm source data, gauge farmer awareness of university customers and assess the impact of purchases on benefiting farmers. The supply team sought to interview up to 10 farmers and ended up targeting 14 and speaking with 8.

Of the eight interview respondents, five were aware of Farm to SUNY. All noted that while it was hard to know the specifics of profitability by product through the distributor, in general product sales to these distributor partners are profitable. Farmers also noted that profitability of an item is highly influenced by market pricing. The three farmers with their own retail farm markets noted that retail was more profitable than institutional sales. In general, the interviewed farmers were 80-100% wholesale. Five of the eight farmers interviewed have capacity for farm visits and interest in marketing with the schools.

All but one of the growers we interviewed was GAP-certified. It is important to note that FreshPoint and Mento require GAP, and Carioto and C's prefer it. Sodexo prefers GAP-certified farmers, but in most cases contracts only with distributors that require it, so we expected most producers benefiting from the pilot to be GAP certified.

Five of the eight farmers were open to farm visits and interested in direct connections with the campuses such as sharing marketing tools, visiting the campus, and meeting with Dining Services.

The interviews were also the means for validating final purchasing and farm source data associated with the "winning products". Farms confirmed that they did grow the products and sell the products to the distributor, but only farmers that are the distributor's single local source for an item could be sure they grew the products purchased by the SUNY campuses.

Goals and Outcomes Achieved

A. Local Produce Procurement Outcomes

The goal was to grow campus spend on up to 6 locally grown produce items at each campus by 25% year over year during the 2014-5 academic calendar at the pilot campuses. The project team achieved this goal.

From August 2014 through May 2015, Glenda Neff and Chris Grace worked closely with the food service directors and distributors to collect procurement data to identify where each campus was achieved growth in fresh and minimally-processed produce purchases.

Total **new spend** reflecting year over year growth across the target "winning products" at the four campuses was **$102,189**. This number reflects a correction from the original report to include $11,789 in onion purchases made by the University at Albany. Total 2014-15 spend on target produce products was **$133,984**. This total is also a correction from the previous version of report that cited $156,000 in total 2014-15 purchases of target local fruits and vegetables.

The tables starting on page 27 summarize the purchases of the "top growth specialty crops" for each pilot campus. Over the 2013-14 school year, the total spend on the target fruits and

vegetables, across the four campuses, was **$30,561**. The additional **$102,189** represents **334%** growth in local purchasing of these target produce items year over year.

New local fruit and vegetable purchases represent 76% of all spend on the discreet set of local produce items tracked through the project.

The stated goal of this project was to increase sales of specialty crops from Upstate Growers & Packers and Hudson Valley Harvest Vegetable to the four target SUNY colleges by 25 percent over current levels.

Five of the 23 farmers selling produce into the campuses were Upstate Growers & Packers farmer members (Lansing Farm, Eden Valley Growers, Tassone Farms, Reeves Farms, and Emmi Farms). Total growth in year over year spend for Upstate Growers and Packers farmers was 618%, growing from $1,206 to $8,661.

Hudson Valley Harvest packages and sells frozen vegetables. There were a number of unexpected barriers to increasing local frozen vegetables sales to these campuses, 1) Albany had already replaced key frozen products with New York products through Purdy and Sons; 2) Oswego was not able to focus on frozen because frozen vegetables are a key component of the campus's Sysco contract that the Oswego team wanted to exclude from the pilot project and 3) Oneonta and New Paltz were working to decrease frozen vegetable purchases.

The project did include two of Hudson Valley Harvest's farmers, Blackhorse Farms and Bulich Mushrooms. None of the Hudson Valley Harvest farms sold product into these schools during the 2013-2014 school year. During the pilot Blackhorse sold 21,365 pounds in tomatoes to University at Albany and Bulich Mushrooms sold 4,080 pounds of mushrooms to University at Albany and SUNY New Paltz. The combined Albany and New Paltz 2014-15 spend on products from the two farms was $33,497.51, all new spend.

Due to challenges with frozen produce, the team focused on fresh cut. Products included sliced and diced onions, peeled and cubed squash, sliced mushrooms, peeled potatoes and shucked corn on the cob. Total prior local fresh cut produce purchases of the items covered in the project was $406. Total purchases for the 2014-15 school year totaled $8,130 for 1902.47% year over year growth.

Table 5: University at Albany Top Growth Specialty Crops

Albany	2014-15			Change over 2013-14				
	Total Units	Total LBS	Total Spend	Units	Total LBS	Total $ Growth	% Growth	Farms
1. Tomatoes	855	21,365	$25,498	855	21,365	$25,498	All new	Blackhorse
6x6	815	20,375	$24,483	815	20,375	$24,483	All new	Blackhorse
Plum	40	990	$1,015	40	990	$1,015	All new	Blackhorse
2. Apples	681	27,226	$21,932	357	14,292	$11,669	114%	Yonder
Local Mixed	548	21,920	$16,336	272	10,880	$8,036	97%	Yonder
Golden Delicious	55	2,205	$2,474	33	1,333	$1,417	134%	Yonder
Red Delicious	49	1,942	$2,194	33	1,322	$1,609	275%	Yonder
Mac, 100 ct.	29	1160	$928	19	758	$606	188%	Yonder
3. Onions	551	24,770	$11,789	551	24,770	$11,789	All new	Torrey
Spanish Onions 50#	439	21,956	$9,907	439	21956	$9,907	All new	Torrey
Red Large 25#	112	2,814	$1,882	112	2814	$1,882	All new	Torrey
4. Chef Potatoes 50 #	539	26,950	$9,737	539	26950	$9,737	All new	Torrey
3. Mushrooms	379	3140	$6,956			$6,956	All new	Bulich
Large Dry 10# Native	2	20	$44	2	20	$44	All new	Bulich
Med Dry 10#	10	100	$181	10	100	$182	All new	Bulich
Sliced Thick 1/4 native	16	160	$327	16	160	$327	All new	Bulich
Sliced 1/8 10#	142	1420	$2,844	142	1420	$2,844	All new	Bulich
Button 10#	21	210	$409	21	210	$409	All new	Bulich

Shitake Native	38	380	$783	38	380	$783	All new	Bulich
Crimini	20	200	$263	20	200	$263	All new	Bulich
Portabella 5# Native	97	485	$1,376	97	485	$1,376	All new	Bulich
Portabella Caps Native	33	165	$728	33	165	$728	All new	Bulich
5. Pears 120 ct.	79	3160	$3,596	76	3040	$3,474	2849%	Yonder
6. Butternut Squash - Pealed and Cut	52	1040	$2,064	52	1040	$2,064	All new	Wertman
7. Cabbage, Green and Red	88	4,258	$1,688	49	2,355	$860	104%	Wertman
8. Kale	20	396	$454	16	312	$361	388%	Blackhorse Wertman
9. Corn, Shucked	23	920	$543	12.5	500	$137	25%	Yonder

Table 6: SUNY New Paltz Top Growth Specialty Crops

New Paltz*	**2014-15**			**Change**				**Farms**
	Total Units	**Total LBS**	**Total Spend**	**Units**	**Total LBS**	**Total $ Growth**	**% Growth**	
1. Mushrooms			$1,044		309	$734	238%	Bulich Mushrooms
Stuffing	20		$195	20	0	$195	All new	Bulich Mushrooms
Portabella	27	135	$334	27	0	$334	All new	Bulich Mushrooms
Sliced	4		$86	4	0	$86	All new	Bulich Mushrooms
10LB White	43		$429	27	309	$120	39%	Bulich Mushrooms

2. Yellow/Green Squash	32		$435	32	0	$435	All new	Buzzanco Farms
3. Apple Cider	23		$543	23	0	$543	All new	Minard Farm
4. Red Onions	58	1450	$834	58	0	$834	All new	Modern Produce Farms**
5. Apples - Mixed Varieties	190		$4,217	86	2756	$1,461	53%	Klein Kill Fruit Farm, Taconic Orchards
6. Roma Tomatoes						$127	All new	Gill Farm

*Where cells are blank, data was unavailable.

**Modern Produce Farms is a broker. They have stated that the onions for Red Barn are local, but did not provide a list of farm sources.

Table 7: SUNY Oneonta Top Growth Specialty Crops

ONEONTA	**2014-15**			**Spend Growth over 2013-14**				
	Total Units	**Total LBS***	**Total Spend**	**Units**	**Total LBS**	**Total $ Growth**	**% Growth**	**Farm**
1. Apples	65,198 apples*		$17,383			$7,547	77%	Yonder Schwabs
Golden Delicious			$2,833					Yonder Schwabs
Red Delicious			$4,948					Yonder Schwabs
Ida Red			$1,119					Yonder Schwabs
NY Style			$6,041					Yonder Schwabs

Honey Crisp			$409					Yonder Schwabs
Macintosh			$657					Yonder Schwabs
Jona Gold			$169					Yonder Schwabs
Rome			$126					Yonder Schwabs
Gala			$179					Yonder Schwabs
Cortland			$295					Yonder Schwabs
Empire			$246					Yonder Schwabs
Macoun			$169					Yonder Schwabs
Fuji			$105					Yonder Schwabs
Gala			$89					Yonder Schwabs
2. Cider	588 GAL		$2,127			$2,018	1851%	Beak & Skiff
3. Pears	27		$968			$968	All new	Yonder
4.Potatoes - Whole	4,950	4,950	$1,707			$1,707	All new	Williams, Torrey
5. Onions – Whole	9,950 LBS	9,950	$5,049			$1,282	34%	Torrey
6. Peppers - Green and Red	3,918 LBS	3,918	$5,946			$5,946	All new	Eden Valley Growers

7. Spaghetti Squash - Whole	1,485 LBS	1,485	$786			$786	All new	DeConinck, Cayuga Produce
8. Butternut Squash -Whole	1,080 LBS	1,080	$524			$524	All new	DeConinck Cayuga Produce
9. BUTTERNUT SQUASH – Peeled and Cubed	360 LBS	360	$233			$233	All new	Martin Farms, Brockport
10. ONIONS (sliced or diced)	NA		$1,200			$1,200	All new	Torrey
*Where cells are blank, data was unavailable.								

Table 8: SUNY Oswego Top Growth Specialty Crops

Oswego**	**2014-15**			**Spend Growth over 2013-14**				
	Total Units	**Total LBS**	**Total Spend**	**Units**	**Total LBS**	**Total $ Growth**	**% Growth**	**Farms**
1. Watermelon	420		$1,890			$990	110%	Tassone Emmi DeConinck
2. Corn on the Cob*	55		$825			$519	170%	Emmi Reeves
3. Onions (red and white)	215	5,375	$3,020			$920	44%	Jacobson
4. Maple syrup	8		$164			$164	All new	Red Schoolhouse
5. Butternut Squash -Peeled and Cut	32	640	$768			$768	All new	Martins Farm
*Where cells are blank, data was unavailable.								

Winning Products

Apples – Three of the four campuses increased purchases of New York apples by more than 25% - Albany (113.7%), Oneonta (76.73%), and New Paltz (53%). Oswego was already purchasing all apples grown in New York State. The total increase in New York apple purchases across the three schools was **$20,677**. Apples were supplied by Yonder Farms, Hudson (Albany and Oneonta); Schwabs Farm, Gasport (Oneonta); Klein Kill Fruit Farm (New Paltz), and Taconic Orchards (New Paltz). Note that Oswego is purchasing all local New York apples through Ontario Orchards, but this was not a growth product for them.

Tomatoes – University at Albany purchased 21,365 pounds of New York tomatoes (20,375 pounds of 6x6 and 990 pounds of plum), additional spend of **$25,497** over the prior year when none of the tomato purchases were local. Blackhorse Farms, Athens supplied the tomatoes to UAlbany through Carioto Produce. New Paltz purchased a small amount of local Roma tomatoes, but it was a new product year over year **($127 in spend)**.

Mushrooms – Two of the four campuses increased purchases of New York mushrooms by over 25% - Albany (all new) and New Paltz (237.9%). The total increase in New York mushroom purchases for the project was **$7,691**. Bulich Mushroom Farm, Catskill supplied the mushrooms to both colleges.

Peppers – Oneonta purchased 3,918 pounds of New York green and red peppers up from none in 2013 for an increase in local purchases of **$5,946**. The supplier was Eden Valley Growers, Eden.

Pears – Two of the four campuses increased New York pear purchases by more than 25% - Oneonta purchased 27 cases of New York pears up from none in 2013 and UAlbany purchased 76 cases up from 3 cases in 2013 - a 2,848.8% increase. Total new spend on local pears was **$4,442**. In both cases, pears were sourced from Yonder Farms, Hudson, NY.

Butternut Squash (Cut/Cubed) – Three of the four campuses increased purchases of New York cut butternut squash. All purchases were new, so the increase was over 0%. The total increase in New York cut/cubed squash purchases for the project was **$3,065**. Oneonta's cut squash was supplied by Martins Farm in Brockport, NY. Albany's squash was supplied by Wertman Farm, Melrose and cut by Capital City Produce based in Menands.

Onions, Whole Yellow and Red – All four campuses purchased more local whole New York Onions - New Paltz (all new local red), Oswego (43.8% growth in red and yellow), Oneonta (34% growth in yellow) and Albany (all new Spanish and red). The total increase in whole onion purchases across the three campuses was **$14,825**. Onions were supplied by Torrey Farms, Elba; Jacobson Farms, Fulton; and Modern Produce Farms, Florida.

Cider – Oneonta increased New York cider purchases by 1,851.4% purchasing 588 gallons and spending an additional **$2,018** on the product year over year. Cider was supplied by Beak and Skiff, Marietta.

Potatoes, Whole – Oneonta purchased 4,950 pounds of New York potatoes and Albany purchased $26,590 pounds. Total new spend on local whole potatoes was **$11,444**. The suppliers of the potatoes were Torrey Farms, Elba and Williams Farms, Marion.

Onions, Diced – Oneonta increased purchased of New York diced onions by **$1,200** in spend. Local diced onions were a new product for Oneonta. The onions were supplied by Torrey Farms located in Elba and processed by Capital City Produce based in Menands.

Watermelon – Oswego grew purchases of New York watermelon by 110% spending an additional $990 on new product. Watermelon was supplied by Tassone Farm, Cicero; Emmi Farms, Syracuse and DeConinck, Spencerport; and Reeves Farm, Baldwinsville. The supply team learned that the watermelon season for New York could be as late as November, so availability of local watermelon for Harvest of the Month was limited. In Spring 2015 the team worked to identify sources for the 2015 Harvest of the Month plans. Glenda Neff was able to connect with Al Lansing, Lansing Farm, through Upstate Growers and Packers, who agreed to grow watermelon specifically for the University at Albany for September 2015. Mento Produce was also able to procure local watermelon from Tassone, DeConinck and Emmi Farms for Oneonta and to be delivered to Oswego through C's Farms. Oswego alone purchased over 1,472 pounds of watermelon at a cost of **$9,837** in September 2015.

Spaghetti Squash – Oneonta purchased 1,485 pounds of New York whole spaghetti squash, all new over 2013-14 purchases. The total cost was **$786**. The squash was supplied by DeConinck Farm, Spencerport and Cayuga Produce, King Ferry.

Butternut Squash (Whole) – Oneonta purchased 1,080 pounds of New York whole butternut squash, all new over 2013-14 purchases. The total cost was **$524**. The squash was supplied by DeConinck Farm, Spencerport and Cayuga Produce, King Ferry.

Corn on the Cob – Oswego purchased an additional 55 bushels of corn for a 169.6% increase in purchases with total grown of **$519** year over year. The suppliers were Emmi Farms, Syracuse and Reeves Farms, Baldwinsville. University at Albany purchased an additional 12.5 cases (500 pounds) of shucked corn from Yonder Farms, Hudson. This resulted in a 25% increase in spend at a cost of $137.

Cabbage (green and red) – University at Albany purchased an additional 49 cases of New York green and red cabbage supplied by Wertman Farm, Melrose. This resulted in an additional **$860** in spend and a 104% increase.

Kale – University at Albany increased purchases of kale by 388% to spend an additional **$361** on kale year over year. While this is a small purchase, we have noted it because it was due to the National Kale Day celebration and opened the door to future local Kale purchases in 2015 due to a positive student response to the kale menu items. The suppliers for the kale were Wertman Farm, Melrose and Blackhorse Farms, Athens.

Maple Syrup – Oswego purchased 8 gallons of maple syrup at a total of **$164** from Red Schoolhouse Maple, Fulton. This was a first-time purchase due to Harvest of the Month.

Of the top products, corn on the cob, apples, mushrooms, winter squash, kale, watermelon and maple syrup were featured during *Harvest of the Month*. Growth in product purchases demonstrates these types of focused promotions that drive menu planning, recipe development and student engagement in product promotion contribute to increased purchases of local items.

B. Farmer Education – Sharing Farm to SUNY Results

The second project objective was to educate at least 50 farmers about the Farm to SUNY project specifically at events including the annual Empire State Fruit and Vegetable Expo and AFT's Harvesting Opportunities conference.

Upstate New York Growers and Packers Produce Coop's Member and Open House Meeting – Upstate Growers and Packers is a farmer-owned statewide marketing cooperative selling all grades of produce from all sizes of farms to all types of wholesale and retail buyers. AFT spoke on Farm to SUNY at the March 2015 member meeting. Coop members include 16 individual farmers as well as Eden Valley Growers, a cooperative of 11 New York vegetable farmers. There were more than 20 fruit and vegetable farmers at the meeting.

Empire State Fruit and Vegetable Expo – Cornell, in partnership with the Empire State Fruit and Vegetable Growers, developed a pre-conference forum on institutional procurement at the 2014 Becker Forum. After consulting with conference leadership and Cornell organizers, the Farm to SUNY team members agreed that the Farm to College presentation fit best with the Becker Forum versus as a separate session at the conference. Unfortunately, fewer than 10 specialty crop producers were present at the Becker Forum.

Harvesting Opportunities – The Harvesting Opportunities Conference was not held in 2014 but project results were shared at the November 4, 2015 conference. The conference included the Farm to SUNY session, *Farm to College: Value Chain Collaboration from Farmer to Student*, focused on the University at Albany produce value chain. Dining Services members, the Sustainability Coordinator and Carioto Produce, the campus's produce distributor discussed the program from identifying and partnering with local produce farmers to working with students to promote the Harvest of the Month produce products. The conference hosted 276 participants, including 29 produce farmers and supportive farm organizations. The Farm to SUNY session attracted 52 session participants. No grant funds were used for these educational activities at the Harvesting Opportunities conference as they occurred after the grant period.

Scaling Up Farmer Outreach –The *Scaling Up Farm to SUNY: Nothing but the Best, Local and Fresh* educational piece has been shared with the more than 50 growers who were part of the initial outreach at the start of the project. These include growers that have existing wholesale channels.

Additionally, the project findings have been integrated into more intensive farmer education through a new 'train the trainer program', the *Market Readiness Training Program*, that is being launched in 2015. AFT worked with Cornell Cooperative Extension to train extension educators and agricultural marketing and economic development service providers who will in turn give workshops to growers to sell their products to schools, colleges, hospitals, food service management companies, food banks and pantries, senior meals and other institutions. Modules

on Communications and Relationship Building, Food Safety Requirements and Pricing include lessons learned through the Farm to SUNY project. The first training was given to 25 professionals on January 27-28, 2016.

Beneficiaries

A. Farmers

More than 23 farmers benefited from the project through sales to targeted SUNY campuses. Note that we were not able to determine the specific sales per farmer due to the sensitivity of distributors sharing the price paid to each farmer. Also, in some cases where an order was supplied by more than one farmer, the distributor was unable to provide the precise number sourced by each farmer for the campus. See Tables 5-8 on pages 26-29.

Table 9: Farmer Beneficiaries

Farm	Location	Products
Beak & Skiff	Marietta	Cider
Black Horse Farm	Athens	Tomatoes, Kale
Bulich Mushrooms	Catskill	Mushrooms
Buzzanco Farms	Kingston	Yellow/Green Squash
DeConinck Farm	Spencerport	Butternut (whole), Spaghetti Squash, Watermelon
Cayuga Farm	King Ferry	Butternut (whole), Spaghetti Squash
Eden Valley Growers	Eden	Peppers
Emmi Farms	Syracuse	Corn, Watermelon
Reeves Farm	Baldwinsville	Corn, Watermelon
Taconic Orchards	Hudson	Apples
Jacobson Farms	Fulton	Onions
Klein Kill Fruit Farm	Germantown	Apples
Lansing Farm	Colonie	Watermelon
Martin Farms	Brockport	Butternut Squash, cut
Minard Fard	Clintondale	Cider
Red Schoolhouse	Fulton	Maple

Tassone	Cicero	Watermelon
Torrey	Elba	Onions (whole and diced), Potatoes
Wertman Farm	Melrose	Kale, Cabbage, Butternut Squash (Cut)
Williams Farm	Marion	Potatoes
Yonder	Hudson	Pears, Apples, Corn (shucked)
Schwab	Gasport	Apples

Five of the 8 farmers we spoke with as part of the project evaluation were confident in saying that sales were profitable for them, but these comments were less specific to specific products and referring more to sales to the distributors, in general. Others felt they did not have sufficient information to answer the question.

B. Campus Community

The core campus participants - Food Service Directors, Sustainability Directors, and students benefited from coming together as a group. They saved resources by collaborating together on promotional efforts and sharing successful strategies as well as barriers to progress.

Food Service Directors

- Data- Food service teams wanted to increase local purchasing and to track progress. Project partners tracked down data from distributors and spent significant time and resources to validate data through calls to the suppliers (farmers, processors and produce brokers). Such efforts also resulted in templates for tracking information that food service staff and distributors could use.

- Menu Planning – The food service directors discussed menu opportunities for Harvest of the Month items and shared recipes for items.

- Accountability - Monthly campus-team calls and full team calls provided regular checkpoints and an incentive to stay on track with project deadlines. Even with a strong commitment to local purchasing of specialty crops and other foods, Food Service Directors had other demands such as large construction of new or redesigned dining halls that demand attention.

"The Farm to SUNY project has helped the synergy between our Office of Sustainability and dining services that didn't exist before. This synergy lead to our campus to take the lead on the Campus Crunch event in October."

- Tim MacTurk, Regional Director, Sodexo at University at Albany

Sustainability Directors

Sustainability Directors benefited in multiple ways from the project:

- *Data* - The sustainability directors use the data captured through the project to meet local food requirements of the Sustainability Tracking, Assessment & Rating System™ or *STARS* Certification from Association for the Advancement of Sustainability in Higher Education (AASHE). Note that the sustainability directors have presented at the last two national AASHE conferences on the Farm to SUNY project due to its broad relevance to college sustainability professionals. Also, SUNY New Paltz is a *Real Food Challenge* school which means it is part of a national network committed to tracking key data about food purchases in order to improve its environmental footprint and have a positive impact on local economies.

- Collaboration on Marketing Activities: Sustainability directors shared the creative process of designing marketing activities and individuals took leadership of various activities such the special events.

"Awareness of the benefits of knowing the source of your food and the manner in which it was produced –this understanding can be applied to other aspects of life such as the source/ingredients of your cleaning products, makeup, lawn/garden maintenance to larger issues such as the source of your electricity/energy."

- Mary Ellen Mallia, Director of Environmental Sustainability, University at Albany

"I went into this program with…an interest in seeing it succeed and seeing patterns and behaviors change in our purchasing and food procurement. While that has happened, and has been exciting to observe, the interest and passion from the student cohort has been incredibly motivating. While the grant-funded portion of this program may be coming to a close, the actions on our campus are not. Were excited to keep this forward momentum going."

- Jamie Adams, Sustainability Coordinator, Oswego

Student Interns
Interns were provided with opportunities for leadership roles in enhancing specialty crop procurement on their campus. They had opportunities to design and run outreach activities, learn about the local food issues and gain research skills through the student survey process.

Students
Students were exposed to high quality, local produce items prepared in a variety of ways. And for events, like the *Campus Crunch*, students were able to be a part of national activities and a much larger movement. Additionally, local food systems concepts are integrated into different college courses at places like the University at Albany. Farm to SUNY provided students with the opportunity to apply classroom concepts at their college setting.

Auxiliary Services
Auxiliary Services leadership benefit from the project because it helps meet local purchasing and sustainability goals. In the case of University at Albany, the contract between Auxiliary Services and the food service provider, Sodexo, includes local food purchasing requirements. Farm to SUNY helped the vendor meet those requirements and hopefully continue to expand purchasing of New York-grown fruits and vegetables.

C. Distributors

Four of the five distributors benefited because the project helped them satisfy demand from key customers and improve their ability to procure fruits and vegetables from New York farmers. For example, the project connected distributors to farmers to fill product gaps so that Carioto Produce is now working with Bulich Mushrooms, Lansing Farms, and Winter Sun Farms (processor) and has a larger local product portfolio for other institutional accounts.

In most cases, distributors were not paying more for products from New York farmers, so they were providing products that customers wanted without additional expense and only in one circumstance did they need to pick up product on-farm so distributors were able to meet the growing demand for New York-grown fruits and vegetables with minimal additional work.

Lessons Learned

A. Farm Source Traceability – Major Barrier to Scaling Up

The Farm to SUNY effort points to a significant need to automate farm source traceability in order for the customer to have timely and accurate information and for the distributors and campus teams to decrease the amount of labor time that is required to complete monthly reports. For this work to scale up, this is critical.

Since distributors do not have ready information in their customer ordering systems about growers, the reporting process requires a lot of manual work that increases the likelihood of errors. Distributor staff was required to look at the purchasing history next to the sourcing history to determine the farms a company was purchasing from at the date of delivery to the college. Similarly, it was difficult to track the origin of products when there were multiple sources for an item, such as two farms supplying corn a distributor. And, since distributors are working with farmer/co-packers, there is additional need to identify actual farm source (today the distributors are not securing this detail as part of their process). Only one distributor that was part of this project, FreshPoint, could run a report on suppliers by customer orders. But, FreshPoint still had the challenge that their system only traces back to their direct suppliers, so with co-packers, individual phone calls are still required to get to the farm source.

Tracing back to the farm is more than a software and technology issue, it is an information and business process problem especially because there are often three to four links in the value chain from farm to college. To address the challenge of farm source traceability in New York , AFT is looking to partner with the Center for Technology in Government at the University at Albany to conduct a 'farm source traceability research and demonstration project'. The project will inform decision making about additional investment in capability in farm source traceability, including

technology and new public policy, might be needed in order to ensure that institutions can identify the source of the local products they are providing and consuming.

B. Good Agricultural Practices Required

While only two of the five distributors required GAP, Sodexo requires GAP compliance, which had significant impact on the project as GAP certification was necessary for three of the four participating SUNY campuses.

C. Farmer – Campus Engagement – Start Small

Frequently, farmers have connections with distributors and not to the end buyers. Farmers were interested in developing direct relationships with end buyers and, as appropriate, farmers are willing to host farm visits or speak on campus. Future efforts should seek to take advantage of simple connections – especially reaching out for marketing materials from farm sources so they can tell the farm's story in promotional materials on college campuses.

D. Contract Requirements Institutionalize the Work

University at Albany was the only campus where the food service management company had language within its contract requiring that the dining team achieve a base level of local purchasing. This formal commitment drives change and is evident by the progress being made at University and the very high level of engagement from dining staff and the Executive Director of Auxiliary Services. It is an outgrowth of student engagement and efforts to change food procurement practices on the campus.

E. State Leadership Can Scale Up The Farm to SUNY Project

Since the start of the pilot, SUNY campuses with local food programs have reached out with interest to join the initiative. Leadership by the SUNY Administration and the State of New York could help coordinate such efforts across campuses, assist with creating promotional materials, organizing student engagement events and coordinating activities across campuses.

Future efforts to scale up Farm to SUNY would also benefit from the kind of messaging associated with a campaign. In order to truly impact student perceptions and heighten awareness of local food efforts, there is a need for *constant* communication and outreach, which the Farm to SUNY team was unable to facilitate at this pilot stage

F. Marketing Needs to Connect with Farmers

The SUNY campus teams want to create effective farmer-centric marketing. Ideally, they want to know the farm supplier in advance of menuing an item - ideally at the time the order is placed. This provides time to create promotional point of sales materials and tell the story of the product and the farmer. This type of marketing has proven effective in successful retail markets, but due to delays in getting farm source information, some Harvest of the Month activities did not include farm source information.

G. Dining Services Commitment Is Critical

Without contractual requirements, the buy local programs are dependent on the strong commitment of Dining Services. When leadership changes in Dining Services, local sourcing can suffer, especially when there are major dining changes such as kitchen build-outs or redesign of meal plans. For example, at SUNY New Paltz, efforts to expand local procurement of specialty crops

and other foods were stalled due to a new Dining Services management's preference for a Massachusetts-based distributor with limited New York supply. (Note that the campus has recently moved to Baldor Foods, which has a stronger track record of purchasing specialty crops from New York.)

H. Balancing Autonomy and Standardization

Individual SUNY campuses desired autonomy in increasing their procurement of New York specialty crops, however, the high level of collaboration and standardization of certain activities allowed for greater impact and efficiency. For example, the campus teams chose to customize the pre- and post- student survey tools —which tracked student perceptions around local food—making it more difficult to determine trends across the colleges and to concisely compile and present survey findings.

At the same time, the multi-campus collaboration allowed for sharing best practices and fostered healthy competition. There was clear pride in their accomplishments, which could be noted by the number of times multiple campus representatives spoke at regional and national events about the Farm to SUNY project.

I. Flexibility Is Key

Due to the nature of agriculture, product harvests can be earlier or later than expected. Also, product pricing greatly depends on supply and changes year to year. As a result, farmers and Dining Service teams need to adjust - for example, menu changes were needed when the New York watermelon selected for meals in September did not arrive until October or when spring greens were not available in May.

J. Multi-pronged Marketing and Outreach Are Key

Student interns stressed that the opportunities to interact with other students or farmers were the most effective marketing, but that social media was still important. Social media was found to be effective at both engaging students and providing positive feedback to the marketing and dining staff. For example, Dining Services staff noted and appreciated the 'likes' on Facebook and positive tweets. Additionally, campuses followed SUNY Oneonta in using the 'Dining Hall Monitors' to promote local fruits and vegetables, sharing information about Farm to SUNY and local specialty crops.

At the same time, the marketing team members were concerned about balancing special events with the everyday work of promoting local fruits and vegetables on the menu through Harvest of the Month. Fall was particularly jam-packed with events. The group agreed that the spring needed to be more about institutionalizing the daily promotional activities versus scheduling joint marketing events - with a focus on marketing the Harvest of the Month, sharing ideas and materials, and tracking progress.

Additional Information/Appendices

- Appendix A: Farmers Expressing Interest in Farm to SUNY
- Appendix B: Farm to SUNY – Farm Supply Survey
- Appendix C: Farm to SUNY New York Product Purchasing – Tracking Sheet
- Appendix E: Sample Marketing Documents
- Appendix F: Sample Local Fruit and Vegetable Recipes
- Appendix G: Farm to SUNY Student Evaluation Pre-Survey (Fall 2014)
- Appendix H: Farm to SUNY Student Evaluation Post-Survey (Spring 2015)
- Appendix I: Farm to SUNY – Farmer Evaluation Interview
- Appendix J: Farm to SUNY Scaling Up Newsletter

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